SUPPLY CHAIN MANAGEMENT TOOLS AND METHODS

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ABSTRACT

In today's business environment, manufacturers need to manage their enterprises as an inseparable part of a supply chain. Key to achieving this is the creation of an extended and integrated information system.

In an attempt to find out what needs to be done to improve current supply chain methods and tools, the current research project 1) reviewed the literature to establish current approaches to Supply Chain Management (SCM); 2) identified what tools and methods are available; 3) categorised the current approaches to supply chain management and established a current practice SCM model; 4) identified the requirements for improved SCM; 5) produced an outline requirements specification for improved SCM.

The research has made a number of contributions to knowledge. A literature survey on the subject of what SCM involves and what a SCM system is was carried out and was followed by the conclusions that existing software systems have not been classified and tested against the criteria of a true SCM system. A survey of existing SCM software solutions provided data for an analysis of what typical SCM applications include and concluded that a comprehensive SCM solution currently does not exist. That conclusion was verified by a survey based on SCM expert interviews. Three case studies were carried out that looked into different parts of the supply chain and demonstrated the significance of advanced SCM functionality for each one of them. The case studies also involved the design and implementation of a supply chain mapping tool and a supplier relationship management tool. Finally, a conceptual specification of an improved SCM system was developed.

The research will be of interest to practitioners in the area of SCM that are looking for ideas to improve SCM procedures and namely, are looking into implementing or developing an already existing software system for SCM. It also suggests ideas for further research, which may be of interest to research students who are interested in the area of SCM.

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LIST OF PUBLICATIONS

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CHAPTER 1 – INTRODUCTION

1.1 THE EMERGENCE OF SUPPLY CHAIN MANAGEMENT

To compete successfully in today's market place, companies need to plan and manage effectively the business activities and transactions, in which they take part. In a manufacturing business, management of suppliers is critical to performance. In the past the majority of manufacturing systems development was focused upon factory operations. The dilemma facing the early system developers was where and how they could best assist production, taking into account both the availability of meaningful data and technical solution limitations.

Early Inventory Monitoring and Control (IMC) solutions were one of the first attempts at computerised material control. Such systems rarely worked well but the development of on-line computer systems removed one of the most fundamental problems, that of the data pipeline. The availability of accurate and timely information on inventory, together with computer-based bills of material, enabled the deployment of a quite different approach to the planning of "material" supply leading to the development of material requirements planning (MRP). The need to reduce costs encouraged companies to look for new ways to reduce inventory holdings and to improve the "cash to cash" cycle time by implementing KANBAN and Just-in-Time Planning and Control systems where appropriate.

MRP was initially introduced to improve the control of material and parts required for assembled products by raising time phased orders for these on the factory and its suppliers. The approach allowed materials and components to arrive in stores a short period before they were required for assembly and eliminated the many component shortages typically faced before the introduction of the system.

This time phased raising of orders on suppliers was an early attempt at supplier management. Manufacturing resource planning (MRPII) developed this supplier management further by the provision of vendor scheduling, whereby a supplier would be reminded of requirements to be supplied the following week or month and informed them of changes to the schedule. Later still, the importance of strong links to the customer was realised and software was developed to improve the links to the firm's customers. Examples with MRPII of this are distribution requirements planning (DRP) and demand management modules.

These, and other, initiatives underpinned the awareness that manufacturing was not an activity based largely within the confines of a factory but something that spanned all activities from supply through to customer delivery. This view was highlighted by Porter with his value chain [Porter, 1985] which attempted to identify how value is added throughout the order fulfilment process. Porter's value chain is shown in Figure 1.1.

The value chain shows the links and interdependencies among suppliers, buyers, intermediaries and end-users. It is useful in that it focuses on these linkages to identify the value that is created for customers and how this in turn creates competitive advantage for the company. The value chain provides a systematic way of examining the activities of not only the company but also the activities of component companies within an overall supply chain (SC).

Effective management of the complete value chain is now essential to the effective running of a successful manufacturing business, particularly in high volume consumer products manufacture and the focus of systems development has moved to supply chain management (SCM) in many industrial sectors.

Supply chain management deals with the management of materials, information and financial flows in a network consisting of suppliers, manufacturers, distributors, and customers. The co-ordination and integration of these flows within and across companies is critical in effective supply chain management. In the last few years, the co-ordination and integration of these flows has attracted significant interest on the part of researchers, management, consultants and practitioners in both academia and industry [Hausman, 2000].

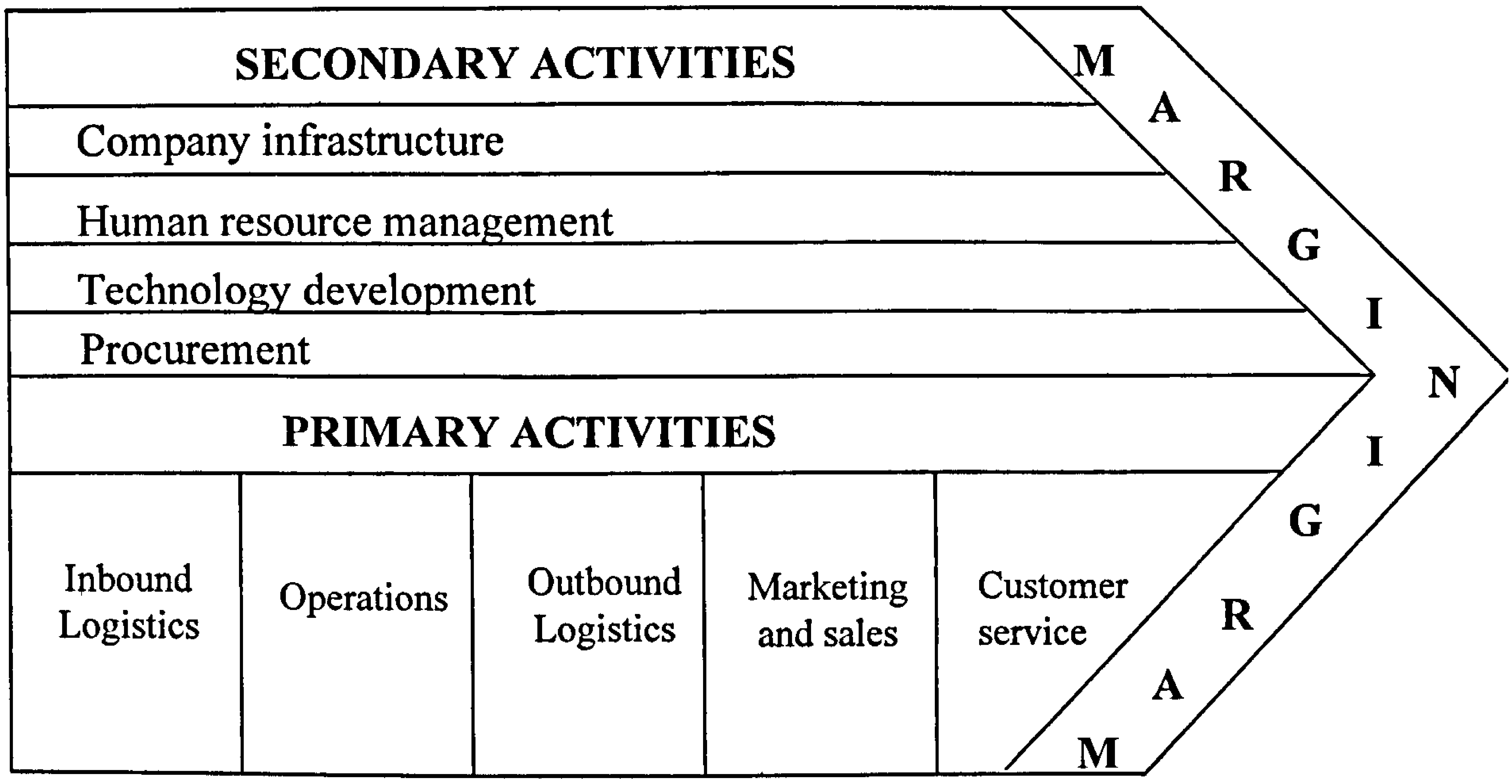


Figure 1.1. *PORTER'S VALUE CHAIN [PORTER, 1985]*

1.2 CURRENT ISSUES AND TRENDS IN SUPPLY CHAIN MANAGEMENT

Competitive manufacturers can no longer afford the inbuilt capacity and inventory buffers that have characterised their supply chains in the past. To avoid those buffers and make the supply chain more efficient, they require up-to-date, accessible information, the ability to collaborate with customers and suppliers, and a deep understanding of the whole manufacturing environment.

That understanding did not emerge and develop easily. In the past, process manufacturers treated their plants as stand-alone units in the production of components and intermediates. That thinking underwent gradual evolution and, as a consequence, in today's business environment, manufacturers in a number of industrial sectors are increasingly realising that they must manage their extended supply chains by:

- Considering all of the plants which contribute to a manufactured product;
- Considering the wants and needs of not only their customers and suppliers but also their customers' customers and their suppliers' suppliers;
- Developing integrated systems which link them to both suppliers and customers.

There are major opportunities to transform supply chain management from a series of periodic and isolated events to an efficient enterprise-wide process that reduces delays, cuts cycle times and increases profits [Blomqvist, 2000]. Companies are realising the need of the ability to make faster, smarter decisions at all levels. Inside the plant gates, companies should generate accurate plans and schedules based on current market and operating conditions. Across the supply chain, companies should optimise their enterprise-wide supply chain by considering all of their plants as a unified manufacturing enterprise, including the flow of materials across multiple plants and storage facilities to develop a coherently functioning enterprise. In this global enterprise, manufacturers should easily link to customers, suppliers and on-line exchanges creating a collaborative, flexible extended enterprise. However, to do this requires a comprehensive range of supply chain methods and tools.

Key to achieving this clear vision and understanding of the entire supply chain is the creation of an extended and integrated information system. This will improve each company's access to information about what is happening up and down the chain. Information technology (IT) systems play a critical role in this as they deliver the networks which allow the integration required between the companies involved. Despite a growing understanding of the role of IT systems in different areas of supply-chain management, IT directors should not underestimate the benefits that full integration can bring. Integration has become a necessary condition to compete and win the race for market share [Yusuf, 1996]. For many businesses, Enterprise Resource Planning (ERP) systems are seen as a key step to the provision of this integrated system. Put in other words, ERP is viewed as MRPII further extended to include all resources which may be constraining the enterprise's capability.

1.3 EXISTING SUPPLY CHAIN MANAGEMENT SOFTWARE

Although today's enterprises are using software to improve their supply-chains, they are not fully addressing the impact other parties in the supply chain have on their business. [Blomqvist, 2000]. Often there is a missing link in the supply-chain among the participants in it. The capability to capture the information is in place but it has not been fed back up and down the supply-chain to enable companies to act in an integrated manner [Jones, 1998].

The broad adoption of core transaction processing systems by organisations, which include ERP systems, electronic data interchange (EDI) and automatic recognition technologies (such as bar-coding and radio frequency identification (RFID) systems), have helped many companies achieve operational integration. But these systems have not addressed the real issue of supplying customer responsiveness in the supply-chain. ERP systems can take care of internally facing functions, but a separate set of applications needs to be integrated before any effective customer-facing service can be achieved. ERP systems can provide the backbone on which customer-driven supply-chain solutions can be based – but they cannot do it on their own [Jones, 1998]. To gain a competitive edge companies must plan their supply-chain to provide an overall customer-responsive order fulfilment process. Improved supply chain methods and tools are a prerequisite to this.

The first advanced planning systems (APS) were designed to remedy this decision support deficiency and improve visibility. Another improvement came via the integration of finite capacity schedulers and the meaning of the APS acronym changed to Advanced Planning and Scheduling systems. While early APS solutions were often just "fast MRP" systems, the computing power now available encouraged some of the traditional approaches to be challenged and improved upon. Modern "enterprise wide" APS solutions cross the artificial barriers between material and other potentially constraining resources and in addition to "enterprise wide" APS solutions we have seen the development of what are often referred to as "point" APS solutions, i.e. solutions which focus on a particular aspect of a business.

1.4 REQUIREMENTS OF AN EFFECTIVE SUPPLY CHAIN MANAGEMENT SYSTEM

According to Schoensleben, the key requirement of an effective supply chain management solution [Schoesleben, 2000] is that they are:

1) real-time - because if the information is old it is worthless for the purposes of relevant decision-making;

2) global - as supply chains span boundaries the solution should have the functionality to observe the processes from a global perspective rather than from the viewpoint of a single company;
3) secure – security is required if sufficient trust is to be established across multiple trading partners.

Schoensleben suggests that the above requirements make it necessary that supply chain management software has some new functions in addition to those of the traditional production planning and control systems [Schoensleben, 2000]:

- Supply Chain Network Design (SCND) in order to plan the logistics and production network;

- Network inventory planning for tasks such as replenishment of the customer's stock by the supplier (Vendor-Managed Inventory (VMI) and Continuous Replenishment Planning(CRP)). To be able to do this, the supplier must have access to the customer's inventory and order data (and the data of any customers downstream in the network).

- Real-time customer service in order to be able to assess the probable service level of open orders with suppliers. To be able to do this, the customer must have access to the supplier's inventory and order data (and the data of any suppliers upstream in the network).

While the basic requirements to an effective SCM system have been identified and define, it is questionable whether the currently available solutions for supply chain management offer these functions and whether they meet the above requirements [op.cit.].

1.5 RESEARCH QUESTIONS AND OBJECTIVES

The analysis of the problems in the area of SCM and the SCM literature review reveal a lack of common agreement on the meaning of SCM, as well as deficiencies in the academic and managerial understanding of the essence of efficient SCM. SCM experts generally fail to highlight and justify the critical importance of effectively managing the supply chain. This has reflected in the SCM practices and the tools that have been developed to assist them. This conclusion prompted the researcher to undertake research to explore in detail the existing SCM literature, SCM software solutions, the experts' understanding of SCM·problems and upcoming solutions, as well as the SCM reality in the industrial world. The study would be used to formulate a realistic picture of current SCM concepts and their application .

The author structured the research process by first setting herself a number of questions that she would attempt to answer in the course of the research. These questions were necessary in order to provide direction to the methodology and work plan of the research process and were formulated as follows:

1. What tools and methods are currently available for supply chain management and how effective are they?

   By answering this research question, it was intended to gain understanding of what the present tools and methods for SCM are and how they are used for the purposes of achieving planning and control of today's supply chains.

2. What are the requirements for the improved planning and operation of a supply chain?

   This question would address the theoretical and practical definition of 'improved' supply chain management and would help to differentiate between the current and the desirable status of SCM.

3. What functions do the current supply chain management software vendors typically provide?

   Addressing this question would involve studying the functionalities of a number of software packages in order to critically assess the definition of SCM software that had been adopted widely in the industrial world.

4. How can the inefficiencies in current supply chain planning be improved? (What additional functionalities do the tools and methods available need to be able to aid the process?)

   The research set out to compare and contrast the scientific definition of SCM with the SCM model of real-world companies, as well as to analyse what the software tools used for SCM do and do not achieve as far as the efficient management of a supply chain is concerned. It was intended that the research would come up with a number of suggestions of how to improve SCM and specifically, what additional features to incorporate into SCM software solutions.

It is appreciated that simple answers to the above questions do not exist. Therefore, the research needed to focus on a number of research areas and come up with a comprehensive report on each one of them in answer to the key research questions. The research area reports were aimed at the achievement of the following objectives:

- To review the literature to establish current approaches to supply chain planning and execution;

- To survey SCM software vendors to identify what commercially available tools and methods for supply chain planning and execution are in the market and their key features;

- To categorise current approaches to supply chain management currently used and establish a current practice supply chain management model;

- To undertake a number of case studies in order to explore real-life scenarios and to test the validity of the conclusions that would result from the previous steps. The case studies were expected to help identify the requirements for improved supply chain planning and execution and provide a test-bed for developing and implementing suggested SCM tools;

- To produce an outline requirements specification for improved supply chain planning and execution based on the current practice supply chain management model.

1.6 RESEARCH METHODOLOGY

After defining the objectives of a research project, it was essential to decide which research methodologies to use for their achievement. Each method of conducting research has its strengths and weaknesses, and that is why it was necessary to work with a combination of methods to make sure that no methodological weakness would be fatal for the research project. To successfully achieve the research objectives, which were listed in the previous section, the researcher decided to employ a number of research methodologies: literature review, questionnaire survey, interview survey, case studies, specification development. The research methods would be used in the process of fulfilling the following briefly defined tasks (Chapter 3 provides more detailed reasoning for implementing the combination of research methodologies):

1. Conduct a literature review in the area of supply chain planning and execution and tools and methods.

2. Undertake a survey of the available tools and methods for supply chain planning and execution.

3. Undertake a series of case studies to identify the current practice in supply chain management tools and methods and to test improvements that the author would suggest to those practices;

4. The development of an outline specification of a model to meet future requirements for supply chain management software which will support the development of the methods and tools currently available.

1.7 STRUCTURE OF THE THESIS

This first chapter introduces the reader to the area covered by the research. It presents the research questions and objectives and the methodology which has been used to tackle them. The chapter also introduces to the structure of the thesis.

The second chapter reviews the literature on supply chain management and the tools and methods which have been used to plan and optimise the supply chain.

Chapter Three discusses the choice of research methodologies which are going to be used for the achievement of the research objectives. The chapter gives an account of their strong and weak points, as well as justification of the selection of the particular method and how it is going to help achieve the research objectives and overcome the weaknesses of other methods used in the research.

Chapter Four describes the design, implementation and analysis of the Survey by Questionnaire. The conclusions following from this part of the research project provide important input into the following Chapters. Chapter Four discusses the design and implementation of interviews with experts and practitioners in the area of SCM. This chapter draws on the conclusions from the previous chapter to modify and complement them in order to form more viable conclusions about the present state of SCM tools and methods.

Chapter Five discusses the findings about the current state of SCM obtained from formal and informal interviews with experts in the SCM field. Apart from the experts' views of the current state of development of SCM, the chapter also discusses the tools and methodologies they apply in their SCM practices and the efficiency of those tools and methods. The chapter introduces the experts' vision of the future of SCM, as well as their ideas of how to improve SCM.

The case studies undertaken within the research are described in chapter Six. Three case study projects carried out in collaborating companies are discussed. The opportunities for those case studies were found in companies that approached the University for assistance with supply-chain related issues. Wherever possible, the requirements of a SCM software system from the point of view of the user were analysed and used as an input into designing and implementing a software tool designed as a "point solution". The ancillary deliverables from the projects, as well as the benefits for the companies are also discussed.

The experience and knowledge acquired as described in Chapters One to Six are summarised in Chapter Seven to come up with a list of requirements of an improved supply chain management system. The requirements are then transformed into a specification for an improved supply chain management tool. The outcomes of this chapter form a part of the suggestions for further development and research in the area of SCM tools and methods.

The concluding Chapter Eight summarises the findings of the research and its significance as a step towards the development of an efficient and effective supply chain management system.

CHAPTER 2 – LITERATURE REVIEW

2.1 INTRODUCTION

The review of the literature sources discussing the role of supply chain management (SCM) and the development of SCM tools and methods emphasises the growing significance of SCM to many business sectors. Careful consideration of the definitions of supply chain and SCM follows and introduces the reader to the opinions of experts leading to the formulation of a definition of SCM which will be sustained throughout this thesis.

The chapter will proceed with a more detailed discussion of the essentials of today's SCM concept. The evolution of SCM, which will be described next, will show how today's SCM evolved along with the development of industrial society.

A major part of the chapter will be dedicated to the evolution of SCM tools and methods and to the description of the current state of SCM software as it is described in the literature.

2.2 SUPPLY CHAIN MANAGEMENT

The origination of the early predecessors of Supply Chain Management dates back to the time when the human race started trading in goods. As primitive as they were, the early supply chains consisted of just a few components and the "management" of those did not require any skills other than those which any human being naturally had. For people who engaged in agriculture, the range of decisions they had to make went as far as the simple considerations of where to grow the plants (location), when to plant the seeds, how to enhance their growth, how to collect the harvest (production) and where to store the products so that they lasted as long as possible and be protected from weather conditions and deterioration (warehousing). The "inventory level" was defined considering a few very simple criteria: the farmer had to make sure that it would be sufficient to last the family until the next harvest, plus a reasonable "safety stock". The excess in production could be traded against other necessary products (e.g. meat from the people who engaged in hunting).

The outline of the simple supply chain above differs substantially from the complex manufacturing and trading processes of modern times. Along with the evolution of supply chains and trade, the management of the supply chains has also evolved. The development of supply chain management as a discipline has been focused on the relationships among functions, activities, companies and intermediaries within developing partnerships and alliances. The successful SCM of present times requires much more elaborated management techniques and methods, which utilise the calculating capacity of advanced information technology. Nevertheless, the basic principles of location, sourcing, production, inventory control and warehousing still apply.

2.3 DEFINITIONS OF A SUPPLY CHAIN AND SUPPLY CHAIN MANAGEMENT (SCM)

There have been numerous attempts to define the supply chain from a number of different perspectives. For example, Rockford Consulting define a supply chain as

> "the process of moving goods from the customer order through the raw materials stage, supply, production, and distribution of products to the customer" [Rockford Consulting, 1999]

The Center for Research in Electronic Commerce sees the supply chain in a similar way:

> "a collection of inter-dependent steps that, when followed, accomplish a certain objective such as meeting customer requirements. " [The Center for Research in Electronic Commerce, 2001]

These definitions show the "dynamic" way of defining a supply chain. The supply chain is seen as a process flow which enables the movement of materials from the source, through production, right until they reach the customer.

A more pragmatic way of defining a supply chain is to view it as a physical network of companies all of which participate in the process of extracting the raw materials, processing them and taking them to the customer in the form of a finished product. Examples of this viewpoint are numerous throughout the Supply Chain Management literature:

> "A supply chain is a network of facilities and distribution options that performs the functions of procurement of materials, transformation of these materials into intermediate and finished products, and the distribution of these finished products to customers." [Ganeshan, et al, 1998]

Lee and Billington have a similar definition:

> "A supply chain is a network of facilities that procure raw materials, transform them into intermediate goods and then final products, and deliver the products to customers through a distribution system." [Lee et al. 1995]

Another group of researchers see the supply chain as a network of semi-autonomous entities and define a supply chain as:

> "a network of autonomous or semi-autonomous business entities collectively responsible for procurement, manufacturing, and distribution activities associated with one or more families of related products." [Swaminathan et al., 1996]

From the above it can be seen that there are a number of views as to what constitutes a supply chain. These views fall into two camps where one group of researchers define it as a process, and the second group view it as a physical network of enterprises.

While both approaches can be justified, the definition which will be adopted for the purposes of this thesis will be the one viewing the supply chain as a process. The justification for this is that the thesis will mainly be discussing the management of information flows rather than material flows and a physical notion of the supply chain will be more inappropriate than viewing the supply chain as a systematic sequence of separate plant processes.

This thesis will consider the tools and methods required for optimising an integrated supply chain process, rather than the tools and techniques applied in running a grouping of physical enterprises.

Therefore, for the purposes of the current dissertation, the author will define a supply chain as:

> The process, which is triggered by a customer order or by forecasted demand, of moving goods from the raw materials stage, through supply, production, and distribution of the required product to the end customer with the ultimate objective of meeting customer requirements profitably.

The definition recognises three essential sides of a supply chain: firstly, it is a process; secondly, it is triggered by a customer order or by a demand forecast and thirdly, the objective of the whole process is to achieve customer satisfaction while generating profit.

Another issue to consider when defining a supply chain as a group of collaborating companies is that the use of the word chain, is suggestive of a row of single members, interacting in a one-way flow, at its simplest a string of a supplier, a manufacturer and a distributor. In reality, such a simplified model hardly exists. The physical side of the supply chain process is represented by a complex network of suppliers, manufacturers, distributors, and their intermediaries. The structure is so complex and dynamic, that it is inappropriate to call it "a chain". A much more appropriate term to use is "network" as the members of a network can be as many or as few as necessary, they can interact in a variety of ways, they can have complex relationships, and the dynamics within a network can change its structure but the entity as a whole will still persist. However, the widely adopted term 'supply chain' will be used throughout the thesis in order to avoid confusion with the term 'network management' which refers to a different field of management science, related to IT networks.

A supply chain, defined as a process rather than a physical entity, involves a number of potential risks which are very important to be understood. Christopher [1991] described four major types of risks in the supply chain:

- Financial risks – the risks involved in keeping inventory, equipment devaluation, reworking stocks and penalties for non delivery of goods.
- "Chaos" risks – risks which are driven by the complexity and uncertainty forces of a supply chain.

- Decision risks – the risks which are a direct result from the existence of chaos because in chaotic conditions, it is impossible to make the right decisions for every player in the supply chain.
- Market risks – the risks of missing the market opportunities presented.

A supply chain with high risk exposure cannot be efficient. A mis-managed supply chain with built in inefficiencies can waste between 25 and 30% of cost [Rolf et al., 2000]. Hence there is a need to manage those risks so that their negative impact is brought down to a minimum. The realisation of that necessity brought practitioners to focus on Supply Chain Management (SCM) as a science which studies the interaction among the processes along the supply chain and co-ordinates them in the most efficient way so as to optimise the performance of the entire supply chain.

SCM is a responsible and difficult task. It requires skills and resources which are often underestimated by businesses. A significant factor for the frequent overlooking of the importance and potential of good SCM is the difficulty in defining what it is and to describe the range of responsibilities which it has for the successful running of business operations.

SCM is defined by Johnson et al. as:

> "managing the links in the product chain - links between suppliers and manufacturers, links between divisions and departments, links between marketing and manufacturing, links between product development, manufacturing and distribution." [Johnson et al., 1995]

and they give the goal of SCM as...

> "not simply to optimise the trade-off of inventory and delivery service... but rather to improve the physics of the supply chain." [op cit.]

However, the above definition is somewhat vague and fails to address the need to achieve the optimum for the whole supply chain rather than for a single key player within it. Furthermore, the definition does not clarify what functions are included in the management of the supply chain.

The Center for Research in Electronic Commerce gives an alternative definition:

> "Supply-chain management is a generic term that encompasses the coordination of order generation, order taking, and offer fulfilment/distribution of products, services, or information." [The Center for Research in Electronic Commerce, 2001]

This process-oriented definition avoids the shortcoming of the one given by Johnson et al. as it does not place the focal point on a single company. Instead, it takes a global view of the process of bringing the desired product to the customer, avoiding the distinction between the companies comprising the supply chain. The definition also lists the activities which are included in management. However, it fails to accredit the need that, when looking at the process as a whole, the objective of SCM is not simply to co-ordinate the activities along the supply chain but also to optimise the trade-offs existing there.

In a similar way, Ross presents supply chain management as:

> "a continuously evolving management philosophy that seeks to unify the business functions within the enterprise and allied business partners along the entire supply channel into a highly competitive, total supply system focused on synchronising the flow of value-added products, services and information with customer demand and the channel's total productive resources." [Ross, 1996],

emphasising SCM as an evolving management philosophy focused upon synchronisation of goods and information.

The above definitions clearly show that the scope of the concept of supply chain management is much broader than a single enterprise and its links to suppliers and customers. It refers to the management of the flows of materials and information from the natural resource stage, all the way through to the ultimate consumer. Thus it may span several enterprises, such as raw material vendors, component and finished goods manufacturers, distributors and retailers [Harwick, 1997].

Customers are increasingly demanding higher and higher service levels from their suppliers, and suppliers are increasingly looking to differentiate themselves from competitors through service performance.

Taking the above into consideration, it should be mentioned that there exists another approach to defining SCM. The definition of Rolf et al. takes that approach by defining SCM as:

> "the ability to get the right product to the right place in the right quantity at the right time for the right cost with error-free documentation". [Rolf et al., 2000]

However, this definition proves to be too limited in its ability to describe how the 'rightness' is achieved.

The definition which the author finds most useful for the purposes of this research is that of Mayer, 2001:

> Supply Chain Management (SCM) is the planning and execution of supply chain activities, ensuring a coordinated flow within the enterprise and among integrated companies. These activities include the sourcing of raw materials and parts, manufacturing and assembly, warehousing and inventory tracking, order entry and order management, distribution across all channels and, ultimately, delivery to the customer. The primary objectives of SCM are to reduce supply costs, improve product margins, increase manufacturing throughput, and improve return on investment.

This definition has the major advantage that it includes both the process and the need for optimisation over the rest encountered throughout the literature and best describes the concept of SCM which will be used throughout the thesis. The definition elucidates the following key characteristics of SCM:

- Management of the supply chain refers to both planning and execution of the supply chain and its activities;
- Co-ordination is important both within the enterprise and among the companies participating in the supply chain;
- Integration of the companies within the supply chain is critical for its success;
- Supply chain activities include all the processes from the sourcing of raw materials until the delivery to the end customer;
- The objective of SCM is to optimise the supply chain for all of the participants in it.

2.4 SUPPLY CHAIN ELEMENTS AND SCM DECISIONS

From the discussion in the previous section, it follows that a supply chain consists of a number of key elements: Supply, Production, Inventory, Location, Transportation, and Information.

Strategic decisions regarding production depend on a long term view of what customers want and the demands of the market. This first stage in developing a supply chain takes into consideration what and how many products to produce, and what, if any, parts or components should be produced at which plants or outsourced to capable suppliers. These strategic decisions regarding production also focus on capacity, quality and volume of goods, keeping in mind that customer demand and satisfaction must be met. Operational decisions, on the other hand, focus on scheduling workloads, maintenance of equipment and meeting immediate client/market demands. Quality control and workload balancing are issues which need to be considered when making these decisions.

Next, an organisation must determine what their facility or facilities are able to produce, both economically and efficiently, while keeping the quality high. But most companies cannot provide excellent performance for the manufacture of all components required within a product because of the range of technologies and competencies required. Outsourcing is an alternative to be considered for those products and components that cannot be produced effectively by an organisation's facilities. The selection of suppliers for raw materials is another task which should be considered carefully. When choosing a supplier, focus should be on developing velocity, quality and flexibility while at the same time reducing costs or maintaining low cost levels. In short, strategic decisions should be made to determine the capabilities of a facility and outsourcing partnerships should grow from these decisions.

Further strategic decisions focus on inventory and how much product should be kept in-house. A delicate balance exists between too much inventory, which can cost anywhere between 20 and 40 percent of its value [Rockford Consulting Group, 1999], and not enough inventory to meet market demands. This is a critical issue in effective supply chain management. Operational inventory decisions revolved around optimal levels of stock at each location to ensure customer satisfaction as the market demands fluctuate. Control policies must be looked at to determine correct levels of supplies at order and reorder points. These levels are critical to the day to day operation of organisations and to keep customer satisfaction levels high.

Location decisions depend on market demands and determination of customer satisfaction. Strategic decisions must focus on the placement of production plants, distribution and stocking facilities, and placing them in prime locations to the market served. Once customer markets are determined, long-term commitment must be made to locate production and stocking facilities as close to the consumer as is practical. In industries where components are lightweight and market driven, facilities should be located close to the end-user. In heavier industries, careful consideration must be made to determine where plants should be located so as to be close to the raw material source. Decisions concerning location should also take into consideration tax and tariff issues, especially in international and world-wide distribution, along with national or local subsidies available for new development.

Strategic transportation decisions are closely related to inventory decisions as well as meeting customer demands. Using air transport may get the product out quicker and to the customer expediently, but the costs are high as opposed to shipping by boat or rail. Yet using sea or rail often means having higher levels of inventory in-house to meet quick demands by the customer. It is wise to keep in mind that since up to 30% of the cost of a product is encompassed by transportation [Rockford Consulting Group, 1999], using the correct transport mode is a critical strategic decision. Customer service levels must be met, and this often determines the mode of transport used. Often, this may be an operational decision, but strategically, an organisation must have transport modes in place to ensure a smooth distribution of goods.

Effective supply chain management requires obtaining information from the point of end-use, and linking information resources throughout the chain for speed of exchange.

Overwhelming paper flow and disparate computer systems are unacceptable in today's competitive world. Fostering innovation requires good organisation of information. Linking computers through networks and the internet, and streamlining the information flow, consolidates knowledge and facilitates velocity of products. Account management software, product configurators, enterprise resource planning systems, and global communications are key components of today's effective supply chain management.

Supply Chain Management ensures that the business processes within a company are part of larger processes that cross company boundaries. Each process is part of a larger process that are information enabled to create better decision making capabilities that work collaboratively across companies.

Supply Chain Management in today's environment is challenged with the integration of different and varying supply chains into a cohesive and coherent operating process. The ability to control and co-ordinate the various supply chains upon which a company depends will give the means of providing competitive advantage, decreased operating expenses and enhanced customer service.

2.5 THE EVOLUTION OF TOOLS AND METHODS FOR SCM

The development of SCM concepts has always been followed by the more practical application of tools and methods used for SCM. As the business manager realised that his company was not a standalone unit but a part of a larger system, he/she looked for new approaches to managing that system and developing new objectives for improvement, as well as new criteria and key performance indicators (KPIs) to measure the future success in achieving this.

The post-World War II supply chain tended to be a set of linear, individualised processes that linked manufacturers, warehouses, wholesalers, retailers and consumers together in the form of a human/paper chain. "People and paper physically connected all of the tiers of the chain together," which often created miscommunication between the front- and back-end processes [Mayer, 2001]. The synchronisation of procurement, demand planning and forecasting, inventory management, shipping and tracking was far from a definitive science. However, as manufacturing and economic growth flourished during the 1950s, there developed a greater awareness of the need for SCM.

Nowadays, manufacturing and supply chain planners have to consider a complex supply chain network as opposed to a single supplier / customer relationship [Sherman, 1997]. The flow of information up and down supply chains is becoming more important than anything else [Christopher, 1992]. Excess inventory is seen as an undesirable result of imbalanced processes and the cost of that inventory is seen to be greater than the cost of managing the flow of information effectively. The predominant emphasis within the logistics strategy of many companies is now to develop the existing Information Technology (IT) applications so as to enhance supply chain performance.

On top of that, business transactions are becoming faster and faster [Gunn, 1994]. Customer requirements have become more and more sophisticated. Product life-cycles have reduced dramatically in most industries and competition has become global.

In the past, focus on output value (local optima, as Goldratt puts it) led to performance measures such as those based on standard hours, direct labour efficiency, factory output value and overhead recovery on direct labour [Goldratt, 1994]. It was identified that the focuses on inventory and customer service were missing. As the attention shifted to inventory and customer service, two principles became obvious. Eliminating inventory at one company led to increasing the inventory held either by its suppliers, or by its distributors so that customer service would be maintained at the same level. But moving the inventory either up or down the supply chain either increased the cost of the end product (and so led to reduced demand) or increased the cost of the materials and component parts bought from the suppliers. Therefore, the cost reduction resulting from holding less inventory did not result in increased profits. Managers reached the conclusion that inventory levels had to be optimised from a global perspective, rather than for a single company. Likewise, increased customer service proved to be a result of the joint efforts of the companies in the supply chain. Managers started looking into the integration of the supply chain as a way of gaining advantage over its competitors. Nowadays, it is no longer a case of one company competing against other companies. It is more and more a case of supply chains competing against other supply chains.

The implications of supply chain integration far exceed those of narrowly focused elements such as information technology, warehousing or inventories. Supply chain integration affects a company's positioning in the market place, its ability to form partnerships and the way it deals with its ultimate customers [Rolf et al., 2000].

With the above, Rolf acknowledges the fact that supply chain concepts can directly result in companies creating value for their shareholders. Effective supply chain management increases profits and market share, strengthens competitive positions and boosts the value of companies. Supply chain integration between customers and suppliers can reduce waste. In line with the same discussion, Rolf suggests to consider the cost structure of manufacturing companies and argues that, as supply chain costs represent more than 60-80% of the cost of delivering the product to the customer, whereas purchased materials account for 50-55%, manufacturing – 15-20%, physical distribution 10%, sales 5%, leaving a profit margin of just 3-4% [Rolf et al., 2000], even a 5% reduction in supply chain waste can double profits. Companies implementing an integrated supply chain management system report the following improvements: reduction in cycle times 35-65%, increased revenues 5-20%, decreased inventory investment 25-55%, decrease of support inventories ("just in case" inventories) 25-65%, increased personnel productivity 25-75%, decreased depreciation from manufacturing equipment 15-40%, decreased scrap from production 25-80%, decreased delivery lead times 25-60%, decreased time to market 25-75%, increased ROI 25-100% [Rolf et al., 2000].

Similar results are reported by various sources. Pittiglio Rabin Todd & McGrath (PRTM), a benchmarking firm, finds the following results as typical of those achievable through implementation of an integrated supply chain: 25% to 50% reduction in total supply chain costs, 25% to 60% reduction in inventory holding costs, and 30% to 50%

improvement in order fulfilment cycle time. The gaps between best in class and average performers on total supply chain cost are as high as 6% of revenue [O'Marah, 2000]. Moreover, a study by Omni Consulting Group concluded that the cost of logistics could be reduced by up to 12.3% for organisations that participate in collaborative supply chain networks [op cit.].

Production planners invariably claim to have picked the optimum production plan considering customer due date adherence, optimal throughput, mix and optimal cash usage. But in manual production planning environments which require anything more than simplistic optimisation rules using 'rules of thumb' and experience, humans rarely achieve optimisation.

However, the results have not been achieved overnight. Both the science of SCM and the software developments, which mirror its development, have undergone decades of evolution. The 1960s saw the birth of the first inventory management software systems, which were typically customized, to aid inventory control in the manufacturing sector [Mills et al., 2001]. In the 1970s, SCM innovations brought forth Material Requirements Planning (MRP) – a system that phases the release of production and purchase orders to ensure that the flow of raw materials and in-process inventories matches the manufacturer's production schedules for finished products. By the 1980s, Manufacturing Resource Planning (MRP-II) was developed, bringing with it systems that could be used for planning all manufacturing resources, including those related to operational planning, financial planning, business planning, capacity requirements planning, and master production scheduling. It was MRP-II's extension into the business enterprise that evolved into an entirely new information technology sector: Enterprise Resource Planning, or ERP [Mills et al., 2001]. Many vendors claimed ERP to be a tool for SCM but, whilst ERP packages typically have a number of SCM modules not usually found in MRPII software, such packages were essentially integrated transaction processing systems with limited decision support capabilities.

Whilst ERP has its roots in the supply chain, as each market has grown, both the interdependence and distinction between the two have also grown. ERP software was originally developed to support transaction processing, data collection and data reporting, but these systems lack real-time analysis and reporting tools to support multiple, highly complex business decisions. Large ERP systems also lack business process flexibility. A major drawback of ERP systems, according to McVey, is that they only provide narrow, one-dimensional planning and are incapable of presenting "multiple constraints simultaneously" [McVey, 2000]. Comparatively, SCM systems were designed to be dynamic – to provide data analysis and planning, business process flexibility and real-time visibility [op cit.] and thus to reflect more effectively the dynamics of business.

In 1988, SCM took a significant leap of its own. Sanjiv Sidhu, founder of Dallas, Texas-based i2 Technologies and a former artificial intelligence expert with Texas Instruments, developed a new breed of software that was based upon the "theory of constraints." Sidhu's product would allow a "company's factories (to) communicate internally, with each other, and with headquarters to improve the flow of materials and orders." [Ian et al., 2001] By 1997, this software had become Internet-enabled. Other firms have since developed expertise in either specific industries, such as consumer goods and process industries, or very specific niches of the supply chain, such as execution and tracking [op cit.].

Manufacturing software also developed in a different direction with a series of highly graphical software products allowing complex optimisation to be achieved. An early example of this was the development of finite capacity scheduling (FCS) products (or finite schedulers) which were intended to assist shop-floor management. As of the middle of 1996, Aston Business School undertook a manufacturing technology survey and reported that about 19% of respondents used FCS products [Burcher et al., 1997]. The reason FCS came into being was that most manufacturing planning systems (including ERP) assume sufficient resources are available when required, i.e. resources have infinite capacity. An MRP system typically takes the orders for products, breaks them down into component parts and calculates when to start making them based on the individual lead times. No account is taken of current available capacity of resources. At the same time that the production order start times are calculated, the materials needed are ordered to arrive in time for the work to start. If there is a delay in production upstream of a particular operation then the materials will be ordered too early. With no concept of bottlenecks available to the planning system, resources become overloaded, queues of work get longer and work in progress increases. Because jobs must join the queues at each process step, orders take longer to make progress, expected lead times are too optimistic and deliveries are late.

Nowadays, FCS software tools are commonly integrated or interfaced into the ERP systems. An FCS tool requires information on resource and work centre capacity, shift calendars, the current usage of that capacity and the Master Production Schedule (MPS), or list of production orders. The FCS generally either returns an optimised version of the MPS back to the ERP system for execution, or takes control of the MPS where the execution system is directly linked to the FCS. Here, the execution system is the shop-floor control and feedback mechanism initiating and recording actual production.

Simpler FCS systems consider all constraints or bottlenecks in production as 'hard' constraints. This means that if the right machine, operator or tooling have to be available at the same time to produce a particular production order then the FCS system has to determine a time when all three resources are free. The more constraints defined for a FCS, the more complex the calculations become. Each constraint can be thought of as another dimension of calculation.

More complex FCS systems, and certainly those built into the SCM systems considered in this thesis, have the concept of 'soft' constraints built in. In a typical manufacturing environment, if a scheduling conflict arises, the manufacturing planners tend to suggest buying in additional tooling. In this case, the tooling can no longer be described as a constraint. It is just a cash-flow 'penalty' for having to purchase the tools. It can be seen that the optimal plan across a series of resources may be a compromise that produces the least penalty. The penalty may be simply in cash terms but the penalties can also include promise dates, inventory shortages, aggregate capacity, safety stocks, excess stocks, and raw material shortages.

On top of these 'hard' and 'soft' constraints there are other scheduling complexities that the better products have to consider such as sequencing environments, e.g. colour sequencing for optimum work centre utilisation. Other constraints can include shelf life, scheduled maintenance, etc.

Advanced FCS systems take into consideration the trade-offs that have to be made when making the decision which functional objective to prioritise. The conflict of management objectives and measures across organisational boundaries across the supply chain is demonstrated in Figure 2.1 [Christopher, 1992]. The arrows point upwards for increase in inventory, customer service and total costs and downwards for resulting decreases in the set objectives. The black arrow signifies the main desired impact of a functional objective, for example, the desired impact of a functional objective to reduce labour costs will reduce total costs but will also have the effect of increasing inventory and decreasing customer service.

Some SCM packages attack some of these conflicting impacts by presenting users with a mechanism to tell the SCM package the weighting the business places on particular management objectives. Thus, if the business objectives of customer service should be considered more important than excess stock then the SCM's optimisation engine will determine that there is a higher 'soft' penalty for customer service and will therefore produce a stocking plan that may require more stock than absolutely necessary because there is a lower 'soft' penalty for excess stocks.

Functional objectives	Impact of objectives on ...		
	Inventory	Customer service	Total costs
High customer service	⇧	⬆	⇧
Low transportation costs	⇧	⇩	⬇
Low warehousing costs	⬇	⇩	⬇
Reduce inventories	⬇	⇩	⬇
Fast deliveries	⇧	⬆	⇧
Reduce labour costs	⇧	⇩	⬇
Desired results	⬇	⬆	⬇

Figure 2.1. ***AREAS OF CONFLICT IN THE SUPPLY CHAIN***

As a conclusion from the review of the evolution of SCM, it is obvious that, in the search of competitive edge, the focus of SCM has expanded to include not only process but technology as well [Parekh, 2001]. More technology providers are promoting the benefits of supply chain management and introducing newer software packages with increased functionality, from which client companies have benefited.

In examining this increased use of IT, it is important to distinguish between two clearly definable groups of IT system solutions that address supply chain issues:

1. Many ERP packages claimed to be SCM products, are transaction processing systems; handling, for example, purchasing, sales and forecasting, shop floor production, quality and inventory transactions. The reason why they are linked to

Supply Chain Management is that they address not just production but the whole value chain of the enterprise – including purchasing, distribution and all supporting activities. In effect, they are enhanced MRPII packages.

2. True Supply Chain Planning (SCP) products are aimed at planning and optimising the supply chain as a whole, usually drawing upon the data set within ERP. The system vendors believe that their products are the true SCM products.

The key to the real definition of SCM software revolves around the system's ability to understand, define, integrate and optimise the complete supply chain from supplier's supplier to customer's customer; to create optimal sourcing and production and distribution plans. The aim of these SCM products is to react to the speed of change across the supply chain and create, for example:

- the best splits across suppliers considering supplier capacity and availability;
- the least 'total acquisition' cost distribution solution;
- the best customer service level that can be achieved with the current demand plan and workforce resourcing rules.

Keith Burgess, a consultant with KPMG's Supply Chain Management Systems Group, defines the goals of advanced SCM systems as being [Burgess, 1998]:

- rapid optimisation of the total supply chain;
- making available 'what-if' functionality – to test the effect of possible events on the total supply chain;
- the ability to cope quickly with unforeseen problems;
- flexible scheduling – allowing for more than the first-in-first-out (FIFO) approach adopted by most MRP systems, and
- the ability to provide accurate and flexible information about the supply chain.

These products logically sit above MRP II/ERP systems but require these transaction based systems to provide the base data on which to enact, record and feedback the optimised demand, supply and production plan.

However, the focus of today's SCM evolution is on technology and little else [Parekh, 2001]. Technology, which has been the primary emphasis, can no longer be a standalone solution to manage supply chain complexity. The investment required in hardware and software for this technology is too expensive. This has been one of the major reasons why penetration of supply chain technology and services in companies regardless of size has been hovering around 20% to 25% [Parekh, 2001].

Another factor for overall low vertical penetration has been that these systems (in their entirety) can take 6 to 9 months to implement and are difficult to understand due to their highly complex and involved nature. Expensive project-based implementation and business consulting is often unaffordable for small to mid-size enterprises, with little or no continuous post-implementation support.

On the other hand, the benefits of Supply Chain Management are so large that most major volume manufacturing companies should be enabled to take advantage of them. But there is much more to an effective supply chain than a technology application, however complex and elaborate. A critical success factor to create and support a competitive, world-class supply chain is to combine technology with effective management, knowledge, and communication. [Parekh, 2001]

2.6 CURRENT STATE OF SCM SOFTWARE MARKET

AMR Research conducted a survey of 100 leading organisations with operational SCM applications. The executives were asked about the key factors that drive supply chain return on investment (ROI) and their experience with the most commonly used supply chain modules [Montgomery, 2001].

The main conclusions made from the survey, were:

- Most users have achieved or are on track to achieve their expected return on investment (ROI).
- Less than 20% of projects are fully operational within six months; typical projects take more than a year to complete.
- The Supply Chain Software market is still fragmented; suites rarely exist.
- Enterprise Resource Planning (ERP) vendors account for 37% of manufacturing supply chain applications but only 6% of wholesale/retail and distribution applications.
- One-third of companies surveyed spend more than $10M annually on supply chain initiatives; 90% plan to make major additional purchases by 2004.

Only 70% of user companies conducted some type of ROI evaluation prior to the launch of their supply chain initiative. 80% of those companies that conduct a formal ROI study on their completed or ongoing supply chain projects have either achieved or are on track to achieve their expected ROI on their supply chain project (56% of the total). Across industry sectors, the average ROI expected is 15% to 19% annually.

AMR Research asked customers to rate the importance of 11 key business metrics in determining supply chain project ROI or the overall success/failure of projects when ROI is not formally measured. In addition, users were asked to rate the effectiveness of supply chain modules in driving improvements in key metrics. The most important metrics in driving ROI include reducing inventory costs and cycle times along with improving fill rates and the visibility of information on production, delivery, and shipment. The supply chain modules that had the largest positive impact on critical operating metrics are demand planning & forecasting (DPF), supply-chain planning (SCP) - including inventory and transportation planning, and order management (OM).

Secondary metrics driving ROI include lowering transportation and warehousing costs, reducing manufacturing overhead and cycle times, improving plant/asset utilisation, and increasing collaboration.

Respondents categorised the extent to which they are realising the benefits from the following operational supply chain modules: DPF, production scheduling, SCP, Transportation Management System (TMS), Warehouse Management System (WMS), and OM applications.

The survey revealed four key ROI drivers:

- Reduced inventory costs - fully one-third of respondents indicate that their DPF systems have greatly reduced overall inventory costs. SCP is rated nearly as high; 32% say that using these systems have had a dramatic impact on their inventory costs.
- Reduced cycle times - OM has the largest impact on reducing overall business cycle times among all respondents. The cash-to-cash cycle begins with order entry and processing. An effective means of processing and reconciling orders, and getting them processed efficiently, reconciled, and fed into supply chain fulfilment and execution systems has had some impact on reducing the cycle time between paying for production materials and receiving payments from customers for goods and services.
- Improved fill rates - most systems have proven to be ineffective in driving dramatic improvements in fill rates. DPF is the highest-rated SCM application, but only 11% of respondents claim dramatic improvements.
- Better information on production, shipment, and delivery dates - production scheduling, OM, and DPF systems all play a significant role in improving the quality and timeliness of the data shared with trading partners on production, shipment, and delivery dates. More than 80% of respondents indicate that these applications are greatly improving this critical information.

According to unsatisfied customers, the chief reason for supply chain project failure is unrealistic expectations set by the software vendor. Across all functional modules, only 16% of implementations took less than six months to fully implement, and almost 20% of projects took longer than two years to become totally operational. Supply chain applications yield results, but it takes experience and time. Greatly improved operations in areas like business cycle times as well as inventory, transportation, and warehousing costs are far more likely to occur in companies that have two years or more experience in using SCM systems.

Some of the main conclusions drawn from the survey are given below:

- The largest implementation performance gap is in WMS functionality - the average actual implementation time is almost three months longer than expected.
- The shortest implementation times are found in TMS applications - the average implementation time is 11 months.
- The longest implementation times are seen in OM - full implementations are taking over 14 months.
- Improved performance relative to inventory costs is twice as likely in companies with more than two years experience of using DPF systems as compared with companies that have had the same systems in place for less than two years (21% versus 45%). Similar results can be observed among companies using SCP applications (20% versus 42%) in relation to inventory costs.
- Companies using DPF systems to drive improvements in their overall business cycle time (cash-to-cash cycle) are four times more likely (7% versus 29%) to have greatly improved results after using the system for two years.
- 19% of companies using SCP systems have greatly improved their business cycle time; in comparison, companies using similar systems for less than two years have not seen significant improvements.
- Companies are much more likely to realise significant benefits when they use Supply Chain Execution (SCE) systems, like TMS and WMS, for longer than two years.

The leading software vendors impacting on the SCM market during year 2001, according to most analysts, were i2 Technologies, followed by ERP vendors Oracle and SAP, and Manugistics [Meyer, 2001]. Other vendors recognised as strong SCM players are Ariba, EXE Technologies, Manhattan Associates, Agile Software, AspenTech and QAD. As an example of i2's strength in the SCM space: as of the beginning of year 2001, the supply chain management revenues of Oracle, SAP and Manugistics combined were less than half of i2's. [op cit.] However, the above should be criticised on the grounds that the statement does not acknowledge the revenue from which part of SAP's product range is meant by "supply chain management revenue". Meyer does not provide the actual revenue data on which the conclusion was based so it is impossible to check whether the statement is correct, applying the definition of supply chain management which has been adopted in the thesis.

Although the supply chain of the 21st century is expected to be a fully automated supply chain "network", Koch and other authors acknowledge that it will be as much about technology and communication as it will be about trust because it has to allow supply chain customer and manufacturers direct access to sales forecasts and cost structures as well as manufacturing and inventory management processes. Though making the technology changes will be difficult, getting suppliers and manufacturers – traditional adversaries – to trust each other enough to share their most sensitive supply chain information in real-time over the Internet will be a real challenge [Koch, 2001]. The supply chain will also become a more collaborative environment in that it will emerge from internal personnel, business partners and the trading community as an opportunity to discover "new, innovative ways of solving business problems and capturing new business" [Gartner, 2001].

Karen Peterson predicts that the strategic supply chain planning segment will grow faster than the rest of the supply chain management market. The supply chain management applications market was $2.2 billion in 2001 and should experience 18% to 20% growth during the next five years. Peterson says enterprises will continue to buy strategic planning software as they look for ways to leverage technology to be more agile and to plan around potential supply chain disruptions. [Peterson, 2001] AMR Research estimated that in year 2000 the Supply Chain Planning and Execution market amounted to $5.20 billion, growing from $3.82 billion in 1999. [Cooke, 2002] Mount et al. estimated that by 2004, SCM spending will match that of ERP, which in 2001 was a $20 billion market [Mount et al, 2001].

2.7 CONCLUSIONS

The literature review brought the author's attention to a number of general problems and some resulting questions in the area of study. In brief, they are:

- SCM as a process covering both planning and execution of the supply chain has not been studied in detail. SCM has only been looked at as a series of management initiatives and this fails to achieve an overall consideration of the supply chain-wide problems of businesses.

- Current SCM tools typically attempt to solve local problems in the supply chain. They are not capable of solving the problems of an integrated supply chain which functions as one single entity. Optimisation is local, rather than across the global supply chain.

- Many existing software packages are claimed to optimise and integrate the entire supply chain. However, the analysis has proved that, generally said, the functionality of the existing SCM software tools helps to run the supply chain rather than plan it. This is particularly true of most ERP packages. While important for the integration of the supply chains, this provides no solution for the need to optimise the structure, planning and construction of the supply chain on the strategic level, as well as to help optimise the running of the supply chain on the tactical level.

- The challenge that stands for current research and development in the area of tools and methods for SCM is to develop tools and methods which:

  1) Optimise the functioning of the supply chain, achieving the best possible scenario, in which all the partners in the supply chain, working in collaboration, benefit, making reasonable trade-offs and balancing the information and material flows to ensure their smooth running.

  2) Provide the functionality of a strategic decision-making tool, accounting for the future plans for the development of the supply chain as a whole, providing advanced simulation functionality to enable modelling non-existing nodes and links on the supply chain map. That tool has to take consideration of financial, as well as geographical and human potential of the enterprise as a whole. Strategic decisions are based on a lot of subjective judgement when performed by human beings – coming from their general knowledge and experience, supported by the data coming from the particular business situation. The design and specification of such tools may involve artificial intelligence (AI) and its advanced applications. As AI is still not developed enough to gain popular implementation, these systems, in the way they look today, are meant to serve as decision support systems. Therefore, they will basically provide analytical data, number-crunching capability, filtering, reporting and visualising the information to present it in the most comprehensible manner to the decision maker.

CHAPTER 3 – RESEARCH METHODOLOGY

3.1 INTRODUCTION

Having discussed the literature about SCM tools and methods and summarised the questions that it had not been able to provide answers to, as well as the problems encountered in defining SCM and developing and implementing SCM systems, the thesis will discuss methodological ways in which those areas will be approached. This chapter will discuss the research methodology which was employed in the research.

Research, as defined by Sekaran [Sekaran, 1992], is "an organised, systematic, data-based, critical, scientific inquiry or investigation into a specific problem, undertaken with the objective of finding answers or solutions to it". The process of researching is a series of steps designed and followed with the goal of finding answers to the issues that are of concern to the research team. Sekaran depicts the research process with the help of the Figure 3.1. below:

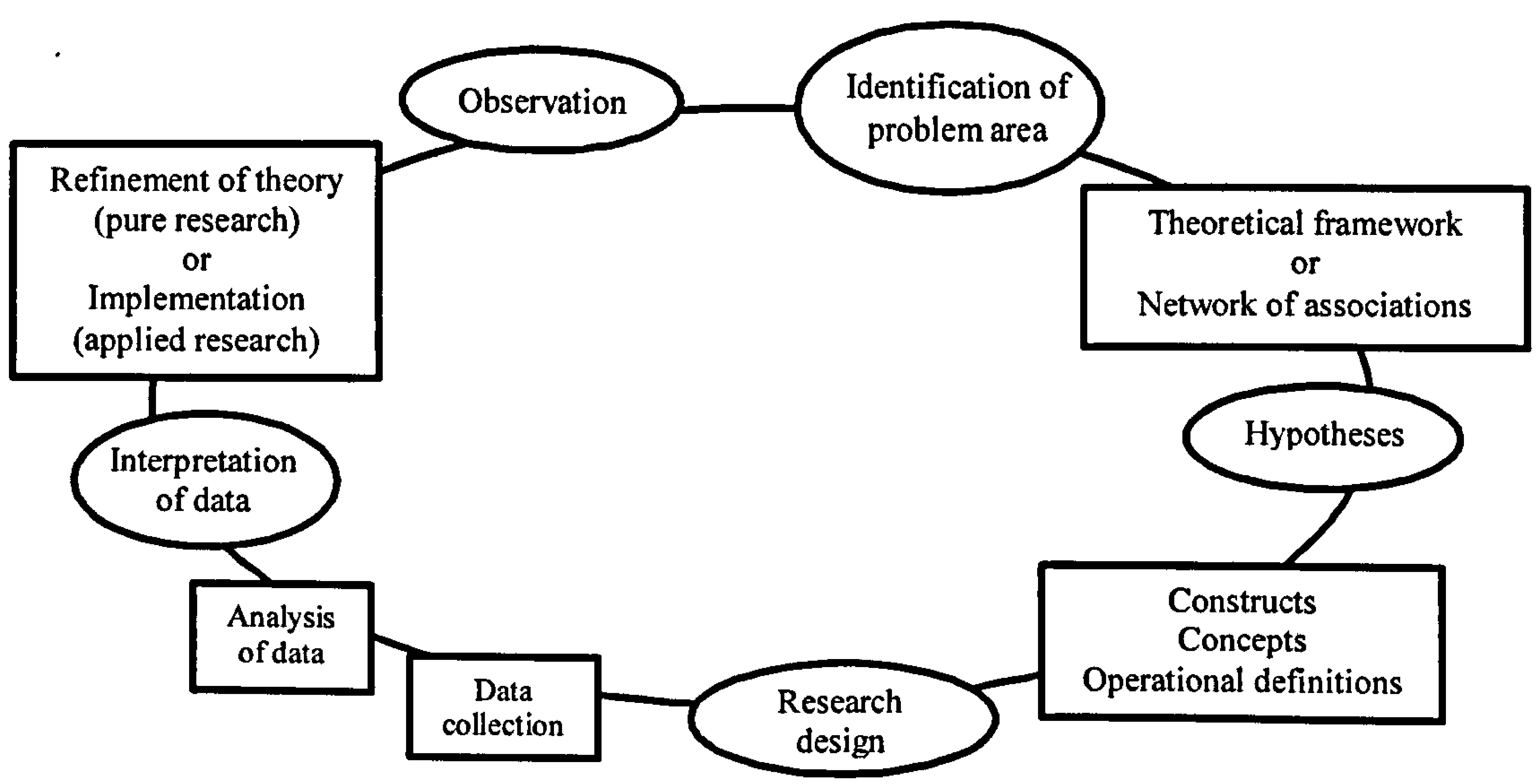


Figure 3.1. *THE BUILDING BLOCKS OF SCIENCE [SEKARAN, 1992]*

As can be seen from the figure above, observation leads to identification of the problem area where the researcher needs to identify clearly and specifically the problems that need to be solved. Once the problems are defined, the need arises to design the research methodology by which they will be tackled [Op. cit].

Research methods refer to the ways in which research studies are designed and the procedures by which data are analysed in order to best achieve the research objectives of the project. A methodology is a set of principles of method that, in a certain particular situation, have to be reduced to a unique method suitable for the given situation [Checkland, 1994]. Therefore, the current chapter should provide a plan for studying the situation, not a simple checklist to be followed. The methodology should enable iterations between the research stages and also define the role of the investigator. Furthermore, it should state the objectives of the study, enable their review and modification, as well as it should provide guidelines for approaching similar problems. [Bignell and Gregory, 1991]

The nature of the research problem and the objectives which were defined at the onset of the research project make it necessary to select a set of research methods that provide sufficient flexibility for the research methodology. As the research started with a broadly defined question: "what are the currently available supply chain management solutions", the approach had to be of a descriptive and exploratory nature, rather than of a quantifying one. However, exploratory research in a specific scientific area requires a broad preliminary research in the specific area and a good knowledge of both the theoretical and practical aspects of the research area. [Robson, 1999] This made it necessary to set information collection and literature study as the first stage of the research.

The initial literature review revealed a number of issues within the area of the research. As a result, a number of research objectives were identified at the onset of the project as described in Chapter One. To help define the requirements of the research and decide on the research methods to be applied to achieve the research objectives, the following questions were formulated:

1. What tools and methods are currently available for supply chain management and how effective are they?

2. What are the requirements for improved planning and operation of a supply chain?

3. What functions are provided by the current Supply Chain Management software vendors?

4. How can the inefficiencies in current supply chain planning be improved?

The purpose of the current chapter is to discuss the choice of research methods which were employed in attempting to answer those questions. The chapter attempts to justify the appropriateness of the selected methods and the way in which they contribute to the achievement of the research objectives.

3.2 DISCUSSION OF RESEARCH METHODS

The research questions, listed above, translate into the following objectives:

Objective 1 (O1): To identify the tools and methods currently available for SCM
Objective 2 (O2): To identify what the requirements are for improved SCM
Objective 3 (O3): To find out what the functions are of the currently available SCM software
Objective 4 (O4): To specify the requirements to future SCM software systems in order to achieve the desired SCM efficiency.

The diagram in Figure 3.2 shows how the research methods relate to specific objectives. The following sections of the current chapter will discuss the ways in which the methods will help to achieve the objectives. The discussion will also cover the advantages and disadvantages of the chosen method, its relevance to the specific area of research, and the challenges which are expected to be faced in the employment of the methods.

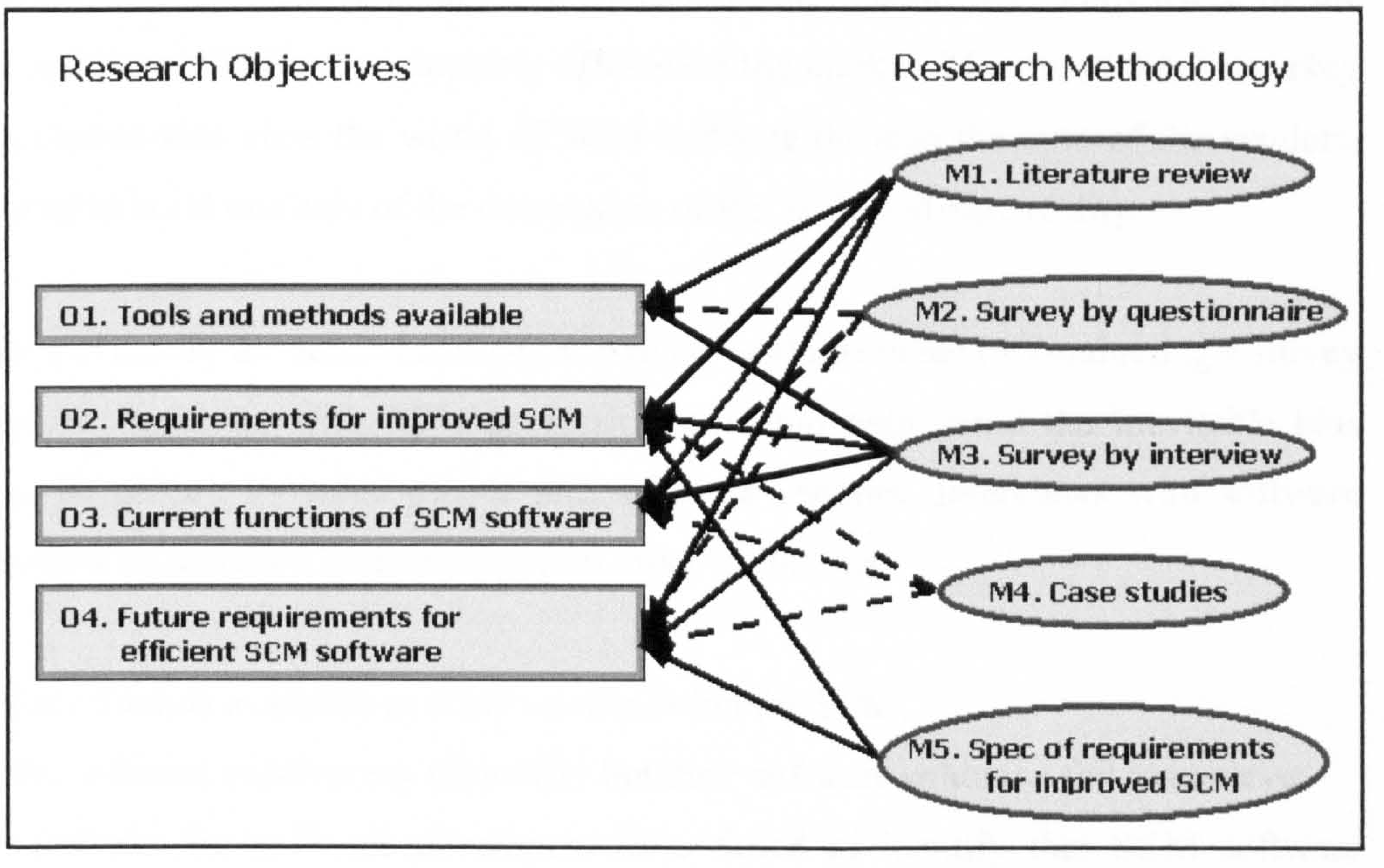


Figure 3.2. ***MAPPING OF RESEARCH METHODS AGAINST OBJECTIVES***

Chapter 1 stated briefly that the above objectives will be achieved by using the following research methods:

Method 1 (M1): Literature review
Method 2 (M2): Survey by questionnaire
Method 3 (M3): Survey by interview
Method 4 (M4): Case studies
Method 5 (M5): Specification of requirements for improved SCM.

The literature review which was undertaken at the first stage of the research, was necessary to provide the researcher with a broad overview of the area of the research, on the one hand, and to help her confirm the existence of the preliminary defined problems, to identify new problems and to help her focus the research on the relevant issues.

The survey by questionnaire would add further knowledge to the knowledge base of the research project by enabling the researcher to gain access to software companies who work in the field of SCM software and to gain further "hands-on" knowledge of the software solutions which were currently offered on the market. The questionnaire survey was expected to also view the world of SCM software through the eyes of the vendors, thus helping to build one side of the description of the SCM software reality.

An attempt to clarify the second side of the reality would be made by conducting a survey by interview. Speaking with SCM professionals would help avoid the inevitable bias added to the picture by sales people and software vendors. Interviews with software experts would be included in the research in order to find out:

1) what they think is available as a software solution for SCM;
2) what the software vendors say they offer but their software solutions fail to achieve;
3) what features the software developers have failed to identify that SCM software packages need;
4) what the potential users of the software would like (or would not like) the software to be able to do.

The interviews also serve the broader goal of gaining insight into how SCM professionals see the present level of development and the future of SCM in general.

The picture of the SCM reality would be completed by studying a number of case studies whereby the researcher would benefit by:

1) gaining hands-on experience in what daily supply chain management tasks involve;

2) gaining hands-on knowledge about the complexity of supply chain strategic planning;
3) endeavoring to study the needs of the employees involved in SCM of software aids for their functions;
4) providing simple but efficient solutions to their most urgent problems;
5) planning for the development of more advanced software solutions which would be applicable for the particular needs of the case study company.

The output from the four methods described above (literature review, questionnaire survey, expert interviews and case studies) was to be summarised and discussed so that the conclusions from the study would provide input to the final stage of the research – the development of a specification for an improved SCM tool. This tool, as stated in the introduction to the research project, is the ultimate goal of the research.

3.2.1 LITERATURE REVIEW

The literature survey is the documentation of a comprehensive review of the published and unpublished work from secondary sources of data in the area of specific interest to the researcher. [Sekaran, 1992]. A literature review is usually the first step of a research project as it helps focus the researcher and ensures that the area of investigation is novel on certain aspects of the topic that were found to be important in the published studies.

The aim of the literature review is to ensure that no important variable is ignored that has in the past been found repeatedly to have had an impact on the problem. A survey of the literature not only helps the researcher to include all the relative variables in the research project, but it also facilitates the creative integration of information gathered from the various sources and gives a basic framework to proceed further with the investigation. A good literature survey thus provides the foundation for developing a comprehensive theoretical framework from which hypotheses can be developed for testing.

Sekaran [1992] summarises the benefits of a good literature review in the following way:

1. It ensures that important variables that are likely to influence the problem situation are not left out of the study.

2. The literature review helps the development of the theoretical framework and hypothesis for testing by giving a clear idea as to what variables would be most important to consider, why they would be considered important, and how they should be investigated to solve the problem.

3. The literature review makes the current research easier to testify and replicate.

4. The problem statement can be made with greater precision and clarity.

5. It eliminates the risk of wasting effort on trying to rediscover something that is already known.

6. It ensures that the research problem is perceived by the scientific community as relevant and of significance.

Whereas research in any area would benefit from the above, a literature review within the research was seen as essential for the successful achievement of the research aims. In the current research project, it was necessary to be undertaken in order to form a systematic view of the current state of research in the area of SCM. Furthermore, the more focused study of literature about supply chain planning and execution tools and methods was expected to help in identifying the level to which those have been studied and to come up with the informed conclusion that the scientific attempt in that area has been very limited. Therefore, the literature study would have the following important functions:

1) Set up the framework of the project;

2) Identify the gaps in the currently existing literature;

3) Update and enrich the author's understanding of the subject matter;

4) Provide a structured plan to the stages of the research which were going to be followed;

5) The chapter on the literature review is absolutely necessary for readers unfamiliar with SCM to gain an insight into the research area.

The process of conducting the literature review starts with identifying the various published and unpublished materials that are available in the area of interest and gaining access to them. The second step is gathering the relevant information and establishing the links between the different sources so that they can be combined in a consistent picture of the research area. The final step is writing up the literature review. [Sekaran 1992]

3.2.2 SURVEY OF TOOLS AND METHODS FOR SUPPLY CHAIN MANAGEMENT

The results from the literature review had to be verified and complemented by a survey of the available tools for supply chain planning and execution. In designing the research methodology, the researcher faced the need to decide on the usage of a viable and yet accessible source of information about the currently available tools and methods for supply chain management.

To find out how supply chain managers managed their company's supply chains, it would be necessary to gain insight into the day-to-day activities included in the area of responsibility of supply chain managers. Textbooks and various publications on supply chain management would give an adequate account of what supply chain management involves and the developments which have already been described and analysed. However, they were unlikely to present the researcher with the opportunity to discover the newest trends in the development of those tools, i.e. they would not be useful for the exploratory study which was intended by the research.

Having in mind the above considerations, an alternative indicator of what supply chain management does was decided to be sought in studying the functionality of the software solutions available to aid those processes. The reason why software is considered to be a good reflection of the newest trends in the development in SCM is that software solutions in their best form are a result of the detailed research into the task which they are going to execute or aid. A survey conducted in Australia by Dawson Consulting (Anderson et al., 2002) shows that managers are turning to IT solutions to improve their supply chain operations more and more these days and that capital expenditure on IT is the primary area of investment in supply chain management. This means that software developers have to keep up with the newest developments in SCM in order to keep their products updated and sought by industrial companies. Therefore, by looking into the latest innovations in the functionality of software solutions, one can get the most reliable picture of the advances in SCM tools.

In this way, the researcher reached the conclusion that studying the most recent trends in the development of supply chain management software functionality would provide additional insight into the new trends in the area of supply chain management. Another important input that was expected from the survey was the information on what was already available and therefore did not need to be developed, thus avoiding unnecessary recommendations at the software specification stage. Therefore, a survey on software solutions for SCM was essential to be included in the methodologies used to reach the research objectives.

The term 'survey' is used in a variety of ways, but generally, it refers to the collection of standardised information from a specific population, or some sample from one, usually by means of questionnaire or interview. [Robson, 1999] Applying the method of survey was expected to be appropriate in the case of the current research because, many sources testify that surveys are well suited to descriptive studies where the interest is qualitative, rather than quantitative [op. cit.]

The aim of the survey was to identify and study the available solutions on the SCM software market. The results of the survey would help to match actual availability to what was claimed to be available by the software vendors. This would give an insight into the demand for SCM software functionality and the extent to which that demand has been satisfied by the software vendors. As such, the survey should be seen primarily as an information gathering exercise.

The survey would use a methodology which is a combination of a questionnaire, expert interviews, and interviews with supply chain managers from industrial companies. The reason for applying a set of survey techniques is that in this way, the subject matter will be reviewed from a multiple points of view, thus helping to avoid bias and the difficulty of ensuring a sufficient response rate.

SURVEY BY QUESTIONNAIRE

Robson (1999) argues that self-completed questionnaires are very efficient in terms of researcher time and effort. The analysis of the responses can also be short if the questionnaire had been well constructed and particularly if computer coding or analysis was employed. However, some problems in using this research method should be borne in mind, such as the fact that the honesty and reliability of the respondents inevitably will vary.

In the design of the survey questionnaire, one of the most important decisions to make was the choice between open-ended or closed questions. In the case of using closed questions, it might turn out that the boxes provided for the response are limiting or the multiple choice questions might not provide an option which is close enough to the respondent's reply. On the other hand, using open-ended questions will make the response analysis much harder and time consuming. [Op. cit.]

Eventually, it was decided to use only closed questions not only because it would potentially reduce the time for analysis of the results but most importantly, it would increase the response rate as it would be less demanding on the time and efforts of the respondents. Another factor, which influenced the decision in favour of the usage of closed questions, was that closed questions would not give the respondent the opportunity to include irrelevant information, as it was thought that most companies would try to highlight what they thought were the best features of their software and avoid confessing that it lacked some of the surveyed features.

The design and distribution of the Supply Chain Management Software Questionnaire was the first step in the survey. The major reason for using a questionnaire for the research was to find out what SCM software vendors offer and how they describe their products. The construction of the questionnaire was preceded by collecting marketing information (brochures, demo CDs, materials from attendance of exhibitions and demonstrations of the software) about the software which was at the time available on the software market and was called by its vendor "Supply Chain Management Software". The primary research showed that the range of software solutions offered on the software market under the category of Supply Chain Management was very extensive and considerably exceeded the researcher's initial expectations. Furthermore, the research proved that establishing contacts with software vendors who do not have a representative office in the UK was complicated due to the communication costs and travelling expenses that would have been involved if the researcher wanted to establish direct contacts with the companies. Language barriers were also expected to be a hindrance to the research process because, although the majority of software systems are designed in English or have English versions, the people marketing them would not necessarily be that well acquainted with the SCM terminology which would be used for the purposes of the survey and the questionnaire. Therefore, the decision was made to confine the research to the boundaries of the United Kingdom. This does not limit the research in any significant way as the number of software vendors who originate from the UK or are represented here by distributors or representative offices form a considerable percentage of all software vendors.

The purpose of the questionnaire was to explore the range of SCM software, rather than describe supply chain management software in detail. Sekaran explains that exploratory studies are undertaken in cases when not much is known about the situation, or when there is no information about how similar problems or research issues have been solved in the past. The current research project involved both situations as a clear definition and categorisation of SCM software was found not to exist in the reviewed literature sources. Furthermore, the existing software solutions had not been assessed in a systematic way regarding their supply chain optimisation and integration capabilities by the time the survey was undertaken. Sekaran says that in such cases, extensive preliminary work needs to be done to gain familiarity with the phenomena in the situation, and to understand what is happening before a model can be developed and a rigorous design set for complete investigation. (Sekaran, 1992)

In developing the survey questionnaire, the researcher had to observe the following considerations:

1) The questions had to be designed so that the answers would not only describe the software solutions participating in the survey, but would also help compare them against each other;

2) The questionnaire had to give the respondents the opportunity to show what differentiates their products from those offered by their competitors;

3) The questionnaire had to help draw a distinguishing line between software which is only transactional or relates only to a single functional area from what could be described as fully functional SCM software;

4) It was necessary to ask the questions in such a way that neither Yes, nor No would seem to be the "right" answer but to encourage the respondents to honestly state their product's capabilities;

5) Open-ended questions had to be avoided as it makes the questionnaire filling more time-consuming. Besides that, the answers to open-ended questions tend to be more difficult to analyse and compare to the answers from other respondents.

6) The length of the questionnaire had to be reduced to a minimum so that a higher response rate would be achieved. The latter was necessary as a reasonable response rate was important to get significant results from the analysis. The initial version of the questionnaire was more than 40 pages long and a careful selection of the most relevant questions proved to be necessary so that finally the questionnaire was reduced to 5 pages in length.

7) It was important to get the vendor's commitment to participate in the survey and provide a contact person within the company. It was considered that contacting that person at a later stage, for more detailed information, would be much easier than trying to get the respondent to give the detailed information at the very beginning. That it why some compromise had to be made with the desired contents of the questionnaire in favour of questions which would be more appealing and interesting to the respondents.

Some further considerations had to be followed regarding the form of the questionnaire (paper copy, on-line form, e-mailed document, etc.) and the way it was going to be distributed. The decision was made to distribute it via post in the form of a paper printout, including a covering letter. E-mail would be cheaper and faster to use but sending hard-copies was expected to attract more attention and thus increase the response rate. Personal interviews based on the questionnaire were also carried out during exhibitions and trade shows of SCM software.

A fact which greatly helped increase the response rate was that the software vendors viewed completing the questionnaire as a marketing and promotional activity because of the statement in the covering letter that the results from the software survey were going to be publicised. However, in the author's opinion, the same factor also made the information gathered with the help of the questionnaire less reliable as the respondents were not always the people within the company who were most knowledgeable about the software features, and their answers were biased by the particular position they held. For example, if a respondent were not sure whether the software had certain functionality, his or her answer would most probably be "yes". In a similar way, if the meaning of the questioned functionality was not clear to the respondent, he was more likely to say that the software had it.

Another aspect of presenting the questionnaire survey as a good opportunity for vendors to market their products was that they would naturally be inclined to stress more on the strengths of their products and avoid mentioning the weaknesses or criticising the dysfunctions. An attempt was made to design the questionnaire so that it would cover every aspect of SCM and would avoid asking only about functions which are known to be well developed in most software solutions.

Despite the above stated limitations of this research method, the questionnaire survey was a useful starting point to the research as it provided a direct feedback from the software vendors and reliable contact information. The exploratory study conducted with the help of the questionnaire and the preliminary collection of marketing information about the software solutions led to the formulation of an aggregated model of existing supply chain management solutions. Later on, that model was compared to the theoretical findings about supply chain management tools and methods from the literature survey. The comparison showed gaps in supply chain management which are not filled by the existing software solutions. Therefore, the research team came to the conclusion that a number of interviews had to be held with experts in SCM consultancy and supply chain managers from industrial companies in order to verify the results of the scientific research and to develop these further. The conclusions drawn from those interviews were the source for the outline creation of an optimised SCM solution.

EXPERT INTERVIEWS

The interview is a conversation with a purpose. According to Robson (1999), one of the reasons why interviews are a very common approach used in research is that they appear to be a quite straightforward and non-problematic way of finding things out. However, Powney and Watts point out that such apparent simplicity may be deceptive. [Powney and Watts, 1987] A comprehensive definition of an interview is the one by Cannel and Kahn, as cited by Cohen and Manion. [Cohen and Manion, 1989]. They say that it is a conversation 'initiated by the interviewer for the specific purpose of obtaining research-relevant information and focused by him on content specified by research objectives of systematic description, prediction and explanation'.

A commonly made distinction between the types of interview is based on the degree of structure or formality of the interview. At one extreme, we have the fully structured interview, with predetermined set questions asked, and the responses recorded on a standardised schedule. The other end of the scale belongs to the unstructured (completely informal) interview, where the interviewer has a general idea of interest and concern, but lets the conversation develop within this area. In-between the two extremes lies the semi-structured interview, where the interviewer has worked out a set of questions in advance, but is free to modify their order based upon his or her perception of what seems most appropriate in the context of the conversation, can change the way they are worded, give explanations, leave out particular questions which seem inappropriate with a particular interviewee or include additional ones. [Robson, 1999]

Another way to typify interviews is to use the classification introduced by Powney and Watts (1987) who use the terms 'respondent interviews' and 'informant interviews'. In respondent interviews, the interviewer remains in control throughout the whole process. All such interviews are necessarily structured to some extent by the interviewer. Both fully and semi-structured interviews are typically respondent. In informant interviews, the prime concern is for the interviewee's perceptions within a particular situation or context. Therefore, the interview will most probably be classified as unstructured.

The types of questions that are usually used in interviews are commonly of the following three types: closed, open and scale questions. Closed questions force the interviewee to choose from two or more fixed alternatives. Open questions offer no restriction on the content or manner of the reply other than on the subject area. Scale questions ask for a response in the form of degree of agreement or disagreement. [Robson, 1999]

Open-ended questions have the advantages of being flexible, allowing the interviewer to make a truer assessment of what the respondent really believes. Open-ended questions can also result in unexpected or unanticipated answers which may suggest unthought-of relationships or hypotheses. [Cohen and Manion, 1989] Those advantages make open-ended questions the preferred type of questions in all kinds of interviews, especially those which are of exploratory character.

Following the questionnaire survey of software products which were at the time offered on the market, an obvious necessity arose to view the situation from a more unbiased, independent perspective – that of SCM experts. For the purposes of the survey, the term "SCM experts" would refer to industrialists and consultants in the area of SCM software who have an access to and experience with the application of an extensive range of software products. The interviewing process was again with an exploratory rather than a descriptive purpose. Therefore, an unstructured set of questions was seen to be more appropriate and useful for the purposes of the research than a structured interview. However, to ensure that there would be a reasonable consistency in the information which was going to be collected, and to make sure that the inevitable change in the researcher's ideas and outlook would not divert the direction of every subsequent interview to trying to confirm what the previous ones have suggested, a guideline questionnaire was prepared before the interviewing process started. On the other hand, it was necessary to bear in mind that the interviewees were people with different backgrounds, expertise and area of knowledge so it was mandatory that, in order to keep the interview relevant to the expertise of the interviewee, the questions and the topics of discussion had to be flexible enough to give the interviewee the freedom to express his or her ideas in the aspect of the supply chain where they are most knowledgeable. Having the above in mind, it was concluded that the interview method which would be used in the research project would best be defined as semi-structured interviewing.

An argument for using open-ended questions in a semi-structured interview was to help broaden the range of problems addressed by the researcher in the research process. Because closed question would primarily be used in the survey by questionnaire and that was assessed to be potentially limiting, it would be sensible to off-set that drawback by using open-ended questions at the interview stage of the survey. Besides that, SCM experts would be expected to be most helpful and unbiased if they were given the opportunity to freely express their views and opinion. Another benefit which was expected from the expert interviews as that the gathered information would add up to the literature review section on the most recent developments in SCM.

By combining the results from the questionnaire survey with the results from the interviews with experts and the information from interviews with supply chain practitioners, the researcher would then attempt to discover any discrepancies between what the vendors offer and what the supply chain managers need. Therefore, the interviews were expected to get an insight into the supply chain manager's tasks and responsibilities, as well as identify with their help which of the areas of their activities involve tasks which can be fulfilled with the help of information technologies.

The interviews with practitioners from industry would be necessary to gain a direct understanding of what today's supply chain management function involved and to compare it with the picture which was drawn from the study of what software solutions are able to do in the same area. That is why these interviews were also unstructured as their aim was exploratory and not descriptive. What would be of high value for the purposes of the research were clear statements of what today's SC managers do and where the difficulties and hindrances to doing their job were. SC managers were thus encouraged to tell about their activities rather than asked a structured set of questions. The aim of this part of the survey was to help find out what tools and methods the contemporary supply chain manager needs to aid his job and whether it would be possible to enable computers to help apply the necessary methodology.

3.2.3 CASE STUDIES

In general, case studies can be defined as 'a strategy for doing research which involves an empirical investigation of a particular contemporary phenomenon within its real life context using multiple sources of evidence.' [Robson, 1999] The case can be anything – case studies can be done on a group, on an institution, on a neighbourhood, on an innovation, decision service, programme and on many other things.

In many studies it is appropriate to study more than a single case. The multiple cases may be attempts at replication of an initial finding, conclusion, etc: or they may build upon the first experiment, carrying the investigation into an area suggested by the first study; or they may seek to complement the first study by focusing on an idea not originally covered. Robson (1999) explains how the case studying activity should be carried out – the first case study will provide evidence which supports some theory about what is going on. This theory, and its possible support or disconfirmation, guides the choice of subsequent cases in a multiple case study. Findings, patterns of data, etc from these case studies which provide this kind of support are the basis for generalisation. Cases are used where either the theory would suggest that the same result is obtained, or that predictably different results will be obtained.

It was initially planned to focus on case studies with companies which are implementing SCM software successfully. That followed from the decision to focus the research on software solutions because they were a good indication of the most advanced developments in SCM. However, with the progress of the survey it became obvious that software vendors are not willing to disclose their customers and to provide the researcher with direct contacts. The explanation, which software vendors most often gave, was that they were observing their customers' confidentiality. It is natural that software vendors were only willing to promote their products in that way only to potential customers.

Furthermore, by providing the researcher with direct contact information, they would lose the immediate control they have on their customers' actions and their systems' performance assessment.

Direct contacts with companies with which the University of Huddersfield and the project collaborators had had long lasting relations also proved to be futile in finding an appropriate company to serve as an example of a fully functional and efficient supply chain management system. These difficulties led the researcher to the conclusion that the initial expectations, that there was a wide utilisation of software systems for SCM within industrial companies, were wrong. Few of the companies, which were available through the supervisors' extensive connections with various industrial bodies and a huge number of industrial companies, were using a system which was close to the definition of SCM tools. That is why it was necessary to conclude that few successful implementations of SCM software exist. Looking from the perspective of software vendors, the picture looked much brighter than the reality proved to be. Along with facing the difficulty in finding a company which would give a good example of fully functional SCM software, the researcher also became aware that focusing on software only would inevitably divert the attention from the primary purpose of the research project – to study and improve current supply chain management tools and methods, rather than just supply chain management software. The above considerations led to the conclusion that using as case studies companies which are not necessarily using supply chain management software would benefit, rather than provide a disadvantage to the project. Therefore, a different approach was undertaken to the case study part of the research: to study the supply chain processes of a few industrial companies of various sizes, coming from various industries and to look into the way they manage their supply chains. The author's expectation was to identify and review the tools and methods which those companies use to aid the process.

3.2.4 OUTLINE SPECIFICATION OF A MODEL FOR SCM SOFTWARE

An outline specification of a SCM method was the ultimate objective of the research project. The method will eventually serve as the basis of the development of a SCM tool and software.

This final stage of the project followed the conclusions reached as a result of the implementation of the previously mentioned methodological approaches. The specification of a supply chain model which is going to help supply chain managers to better execute their complex tasks, was based on the combination of the research findings and particularly on the outcomes from the case studies. The model represents a schematic description of the modules of a SCM tool, as well as the interactions and data flows between them. The model sets out the position and role of the optimisation engine within the structure of the entire tool. It also provides guidelines on what modules are essential and which ones are optional. The software survey gave sufficient information to prove that such a tool for SCM doesn't exist at present. The interview survey and the case studies which followed proved the necessity of it.

3.3 CONCLUSIONS

The research methodology which has been discussed in the current chapter was expected to provide a feasible way of achieving the research objectives. Overall, the researcher was confident that the initially designed methodological approach to the research was sufficiently well-thought out and well-structured to enable the research to come to a successful end by coming up with findings and conclusions which would strongly benefit the future development of SCM and the evolution of the tools and methods for SCM in particular. The limitations of the selected methods were expected not to be fatal for the research at the time when the research methodology was designed. Those limitations will be discussed in greater detail in the respective chapters together with some unforeseen difficulties that were faced. The following chapters will also discuss any additional methods that were employed in the attempts to overcome those difficulties, as well as some minor alterations to the design of the research methodology which proved to be necessary during the research process.

CHAPTER 4 – SURVEY BY QUESTIONNAIRE

4.1 INTRODUCTION

Supply Chain Management software applications claim to provide real-time analytical systems that manage the flow of product and information throughout the supply chain network of trading partners and customers. The chain includes many different functions, such as sourcing, production planning, warehousing, transportation, demand forecasting, and customer service. Supply chain management applications empower managers to streamline operations and better understand their strategic decisions. Current literature and publications state that the present Supply Chain Management solutions market is fragmented along these functional lines with most vendors selling into specific spaces. The trend, however, is to consolidate these disparate functions into a comprehensive supply chain planning suite.

The aim of the present survey is to identify and collect general information about the solutions currently available on the market which support supply chain management. The analysis of the responses to the questionnaire will help understand better the functionality and scope of the supply chain planning and execution software products and establish the current supply chain management practice.

4.2 PRELIMINARY RESEARCH OF SCM SOFTWARE FUNCTIONALITY

Before the survey by questionnaire was carried out, a preliminary research of SCM software functionality and available modules was carried out. This preliminary exercise was necessary and was included in the action plan of the software survey for the following reasons:

1. It would provide an insight and more detailed knowledge in the area that was going to be investigated later;
2. It would help to make some preliminary hypotheses and conclusions which would have to be verified by the actual questionnaire analysis;
3. It would help to structure the survey questionnaire in a logical and competent way. Furthermore, it would help focus the researcher's attention on the most important functions of SCM software and avoid asking questions which would be irrelevant to the survey in the questionnaire;
4. It would help to focus not only the survey by questionnaire but all the parts of the software survey on the same issues and on the achievement of one common goal by defining clearly the facts which are already known and the questions which would need to be answered;
5. It would familiarise the researcher with the available promotional material and help her avoid asking irrelevant questions about the software specifications and about the software vendor itself.

Overall, the preliminary research of SCM software functionality was planned in order to add some specific facts about existing software solutions to the literature survey and to strengthen the conclusions which were reached at that previous stage of the research project. A major outcome of both the literature survey and preliminary research of SCM software functionality was the construction of a schematic representation of the current status of an aggregate SCM solution offered on the software market. This schematic would serve, firstly, as a hypothesis which would further be tested by the survey by questionnaire, the survey by interview and the case studies, and, secondly, as a guidance framework in positioning every solution which would be included in the survey by questionnaire.

The schematic representation of the aggregated current state of existing SCM software is designed to identify and position all variations of software which would fit into the category "Supply chain management software" into a grid according to their tactical/strategic and value-chain definitions. The horizontal axis of the grid lists all the parts of Porter's value chain. Due to the fact that the original version of Porter's value chain is two-dimensional and the categories had to be fit into a one-dimensional line, some adaptation proved to be necessary. That is why the horizontal axis starts with the support activities in a supply chain (i.e. Employee Management, Finances, Product Development) which would naturally cover all the physical flows in the value chain. The rest of the axis lists the activities which constitute the physical flow of materials throughout an enterprise (starting with Sourcing, going through Manufacture, Distribute, Customer Service and ending with Marketing the Product) (Figure 4.1). The vertical axis represents the level of strategic, planning or execution relevance of the SCM tool.

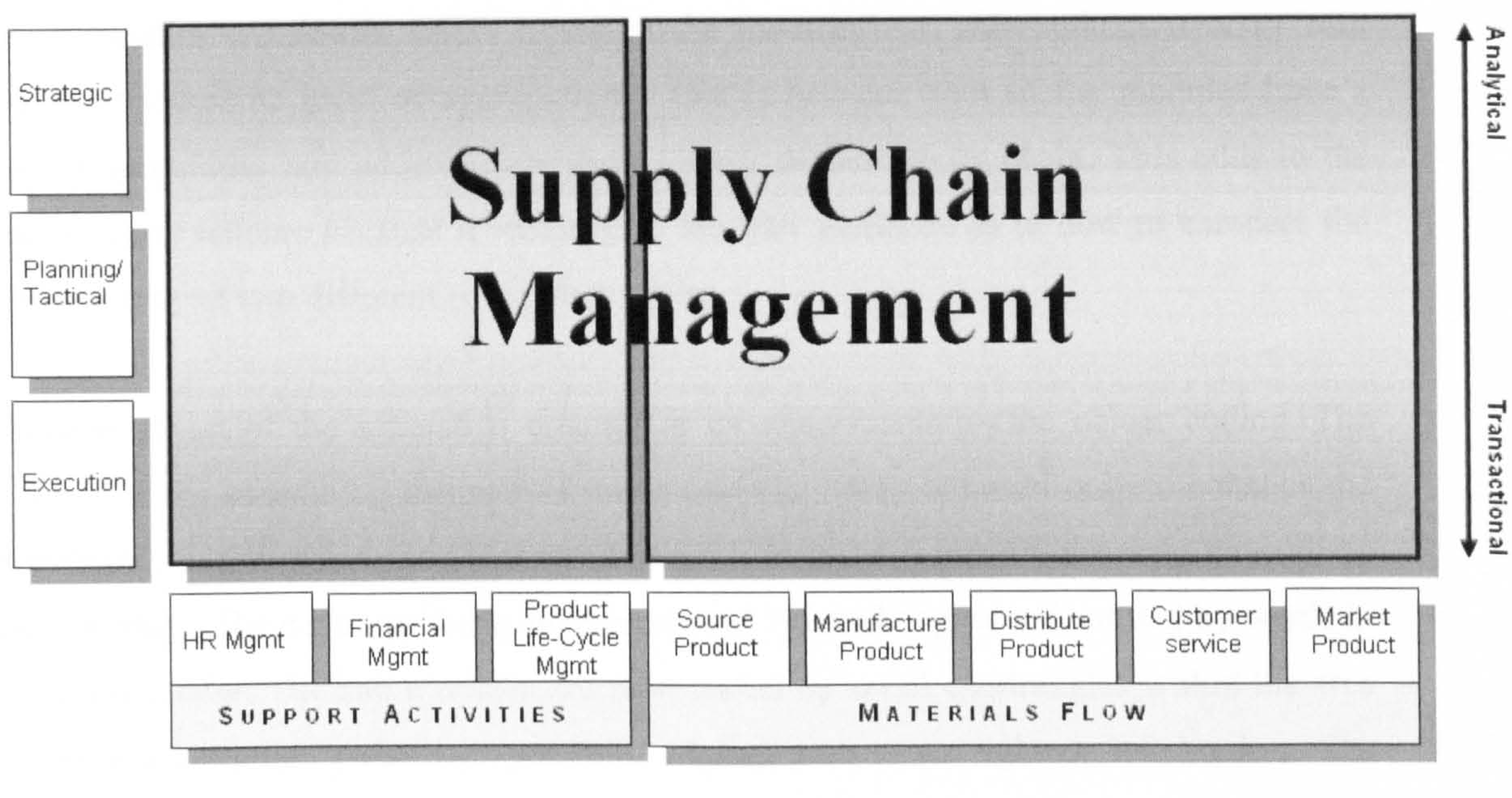


Figure 4.1. ***SCHEME TO REPRESENT THE CURRENT DEVELOPMENT OF SCM SOFTWARE***

The full version of the diagram was intended to depict the location of each of the popular SCM software modules in relation to the rest of the modules and to place it within the framework of the author's notion of an advanced SCM software tool (Appendix 4.1A). The horizontal axis shows which areas of the entire supply chain the particular module is designed to address. The vertical axis shows whether a particular module of the system is designed to support execution, planning or strategic decisions. The more strategic a module is, the higher up next to the axis it is positioned. Therefore, modules which are at the top of the scheme can be described as "analytical", whereas modules which are more towards the bottom are "transactional".

In the diagram, an attempt was made to name the modules after their most widely used acronym. However, most of the acronyms are not very popular and are not used in all SCM societies. Therefore, to make it easier to understand the functionality of the particular module, the full name is stated rather than the acronym. The scheme should be read together with the full listing of the modules and the explanation of their functionalities (Appendix 4.1B). Some of the modules and sub-modules overlap with others at the same level of aggregation – this is because both of the modules have a similar popularity and address overlapping areas of the supply chain. This adds to the value of the scheme because it would give the user guidance as to how to compare the functionality of two different software modules.

Another aspect of the scheme is crucial for its understanding– the colour coding. The colours in the scheme by themselves mean nothing – they are used only to enhance the appearance of the scheme and to make it easy for the user to identify the areas covered by each module. The major modules are represented by quadrangles and entitled by words in the same colour. The sub-modules are represented by small quadrangles within the area of the main module (wherever possible, aligned next to its right or left border). The borders of the small quadrangles are coloured in the same colour like the main module's colour but their names are written in black.

The detailed scheme was originally produced as an A2-sized poster. However, it was resized to fit a standard A4 page for the purposes of this thesis (Appendix 4.1A).

4.3 SURVEY QUESTIONNAIRE ADMINISTRATION

The questionnaire (Appendix 4.2) was sent to 201 companies in the first round (see Appendix 4.3). The companies approached were software vendors who state that they offer a supply chain management solution. The companies were business software vendors or distributors. Their software offered solutions in a very broad business area. The reason why this was done was to make sure that all types of business software which would be called SCM software by their authors, were included in the survey.

The information about the companies (product offered, address, telephone, etc) was gathered mainly through Internet search. Out of the 201 distributed questionnaires, 12 came back as the addressee had moved out or simply the postal address was not recognised by the mailing company. (Appendix 4.4) Three of the companies replied that they did not currently offer any solution in the area of Supply Chain Management.(Appendix 4.5)

Out of the 201 companies, 30 replied giving the name of their current SCM solution and all the information that was sought by the questionnaire (Appendix 4.6).

In order to improve the response rate of the questionnaire, a second round of questionnaires was distributed to 48 of the companies which were included in the first round and which did not respond to the questionnaire (Appendix 4.8). The selection of those companies was based on the author's experience in the field which has been gained during the project up to then – only the most relevant companies (which were clearly SCM software vendors) were included. The covering letter of the second round of questionnaires is shown in Appendix 4.7.

A total of 6 software vendors (Appendix 4.9) replied to the second round of the questionnaire which brings the total number of respondents to 36 and a response rate of 18%. A response rate of 18% to such a kind of a questionnaire survey should be considered to be sufficient for the following reasons:

1) As was pointed out a number of times before, the software survey undertaken is of an exploratory and descriptive character rather than quantitative. The results, which are sought by means of the survey, are not of statistical importance and therefore, the response rate of 20%, which is usually important for a statistical survey, does not apply in this case. There was no target response rate set out at the beginning of the research. Instead, the researcher was trying to collect as many responses as possible in order to enhance the informative qualities of the questionnaire analysis. The relatively low response rate, which was eventually achieved, does not invalidate the conclusions and this will be discussed later on. The negative impact will only be in the range of features of currently existing SCM software that are going to be discussed. It is possible that a specific feature could have been omitted from the analysis but the probability that it would have a major impact on the conclusions is small, in the author's judgement.

2) The actual response rate to the questionnaire is considered to be much higher, having in mind that a certain part of the companies which were sent the questionnaire did not reply simply because they did not think the survey is relevant to the fields in which their software offers solutions. Because of the fact that the introduction to the questionnaire presented the survey as a good opportunity for the respondents to gain publicity and to advertise their products, it is believed that all those companies which think they offer SCM software would have used the easy and, practically, free way to promote their software. The questionnaire did not demand any information which would potentially be sensitive and confidential. Therefore, we believe that if not all, then most of the software vendors which were approached to participate in the survey and had a relevant software solution, would not miss the opportunity and that the survey analysis is actually based on comprehensive data from the research field.

4.4 ANALYSIS OF THE RESULTS

The present section reports on the findings of the survey. It aggregates and analyses the responses given by software vendors and draws important conclusions about the current state of development of SCM software.

4.4.1 TYPE OF THE SYSTEM

The first question about the SCM software, which the respondents were describing, was about what type of system they would call their product. The respondents had a choice of 8 acronyms which are well-known and widely used by experts in the field. Those included: ERP, SCP, SCE, APS, OMS, MES, WMS and TMS. Brief definitions were provided describing what each term means, as follows:

Enterprise Resource Planning (ERP) - a transaction based system which works at the highest corporate level providing a planning and scheduling backbone for general administrative functions from financials to customer orders

Supply Chain Planning (SCP) - helps plan and design the supply chain at the strategic level – aids general long-term decisions regarding the structure of the supply chain

Supply Chain Execution (SCE) - helps make decisions regarding the operation of the supply chain and the execution of daily activities, the structure of the supply chain is considered as fixed in making Supply Chain Execution Decisions

Advanced Planning and Scheduling (APS) - creates production plans and schedules in manufacturing plant. Use constraints and business rules to optimise the schedule

Order Management Systems (OMS) - validates and prioritises customer orders for the next three software classes that get the work done

Manufacturing Execution Systems (MES) - receives orders and dynamically manages resources on the shop floor from equipment and labour to inventory needed to fill those orders

Warehouse Management Systems (WMS) - directs and controls in real time all activities and resources within the warehouse

Transportation Management Systems (TMS) - focuses on controlling costs and managing inbound, outbound, and intra-company movement of goods

The bar chart in Figure 4.2 shows the main results from the responses to that question. The figure shows the weighted importance of each of the types' functionalities. The respondents were first asked to indicate whether or not their SCM solution could be said to be any of the types described. After that, they were asked to rank the level of development of that function of their software from 1 to 5, 1 meaning the function is still under development and 5 meaning that it is the main focus of the system. Then an average was calculated for each of the types and the results are shown as bars on the graph. If the function was not applicable to the particular system, it was given a rank of 0.

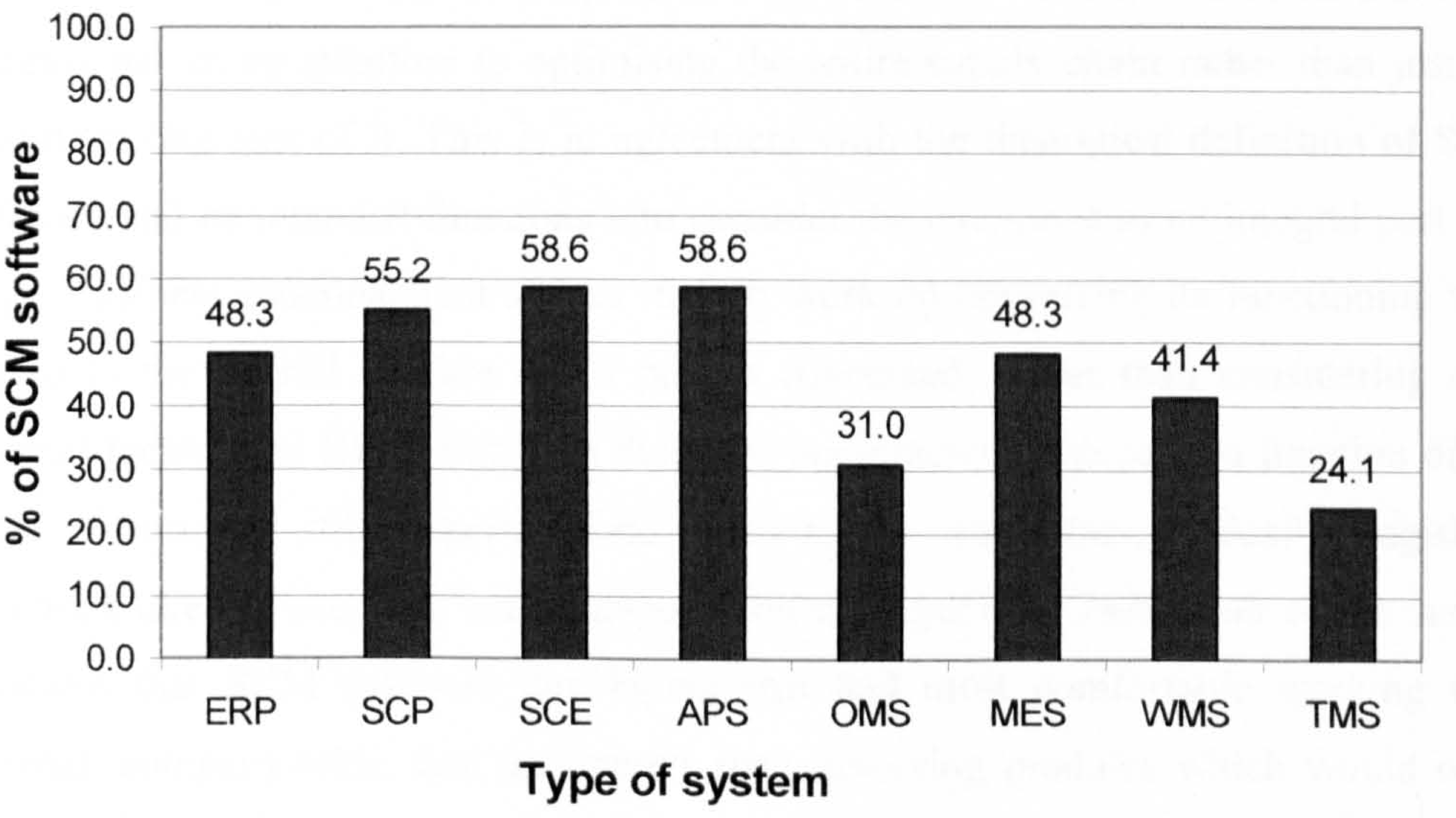


Figure 4.2. *VENDORS' VIEW OF SCM SOFTWARE FOCUS*

The following conclusions can be drawn:

1. The most common type of system promoted as a SCM software product is APS. Therefore, the software vendors agree that a good SCM tool should possess both planning and scheduling features.

2. APS involves both planning and scheduling (execution) but the software vendors give preference to the execution function of their products since they are more often SCE than SCP tools. This supports the initial hypothesis that the features of SCM software, which support strategic decision-making, are relatively neglected and still under-developed by SCM software developers. One of the reasons why this is the case is that the majority of today's SCM systems have developed from the past MRP II and ERP transaction processing systems. The truly "advanced planning" and "optimization" features are a relatively new field of development and cannot be expected to be at the same level of sophistication as are the older, already well established execution modules.

3. The lower ranking of MES in comparison with SCE leads to the conclusion that SCM systems pay more attention to optimising the entire supply chain rather than just the manufacturing part of it. This is in agreement with the theoretical definition of SCM software and its intended functions – to consider the enterprise as an integral part of a larger business establishment and as such to work on optimizing its functioning with regard to the overall welfare of all parties concerned, rather than considering only internal factors and KPIs. But even then, the manufacturing execution function of the SCM software is still important and ranks higher than other, typically, logistical functions like warehousing and transportation management. This result of the survey indicates that SCM software developers still feel most comfortable working with internal, company-wide data parameters than involving modules which would often depend on acquiring data from companies which are external, though still directly linked to the company's operations.

4. Transportation management is the least popular function of a SCM system. Again, this observation shows that the typical SCM software system focuses away from one of the major fields of SCM which offers a huge scope for improvement. Why would

warehousing be almost twice as popular as transportation? The most probable reason why this appears to be so, in the author's opinion, is that warehousing is more often done in-house than subcontracted, whereas transportation usually involves a third party logistics services supplier and its scope reaches far beyond a single company's boundaries. That is why transportation is more difficult to control, plan for and most importantly of all, acquire data about, on which to base optimization decisions.

5. Surprisingly, a lot of software vendors still don't see ERP and SCM systems as complementary but as analogous systems. They tend to regard SCM as a more advanced substitute for ERP.

4.4.2 FUNCTIONS OF SCM SYSTEMS

The next question enquired about the specific functions of the system under inspection. The respondents were asked about functions in three different groups: Sales and Logistics, Materials Management and Supply Chain Planning.

Figure 4.3 represents the percentage of SCM software for which vendors claim to have the particular functions identified in the survey. The most popular functions are in the section of Supply Chain Planning – this testifies that the focus of SCM software is strategic rather than on execution functions. However, within these functions the main emphasis is on inventory and production planning – functions which are located in-house, whereas, typically, external supply-chain functions like demand planning and enterprise-wide planning are less popular. It identifies a need to focus on the global, integrating aspect of supply chain management rather than company-centred planning.

The sales and logistics software functions listed in the questionnaire were popular representing an average of 64% of the investigated software systems. Compared to the 75% rate of supply chain planning functions, the outbound functions of SCM software seem to be less popular but not as unpopular as appear to be the materials management functions, ranking at an average of just 54%.

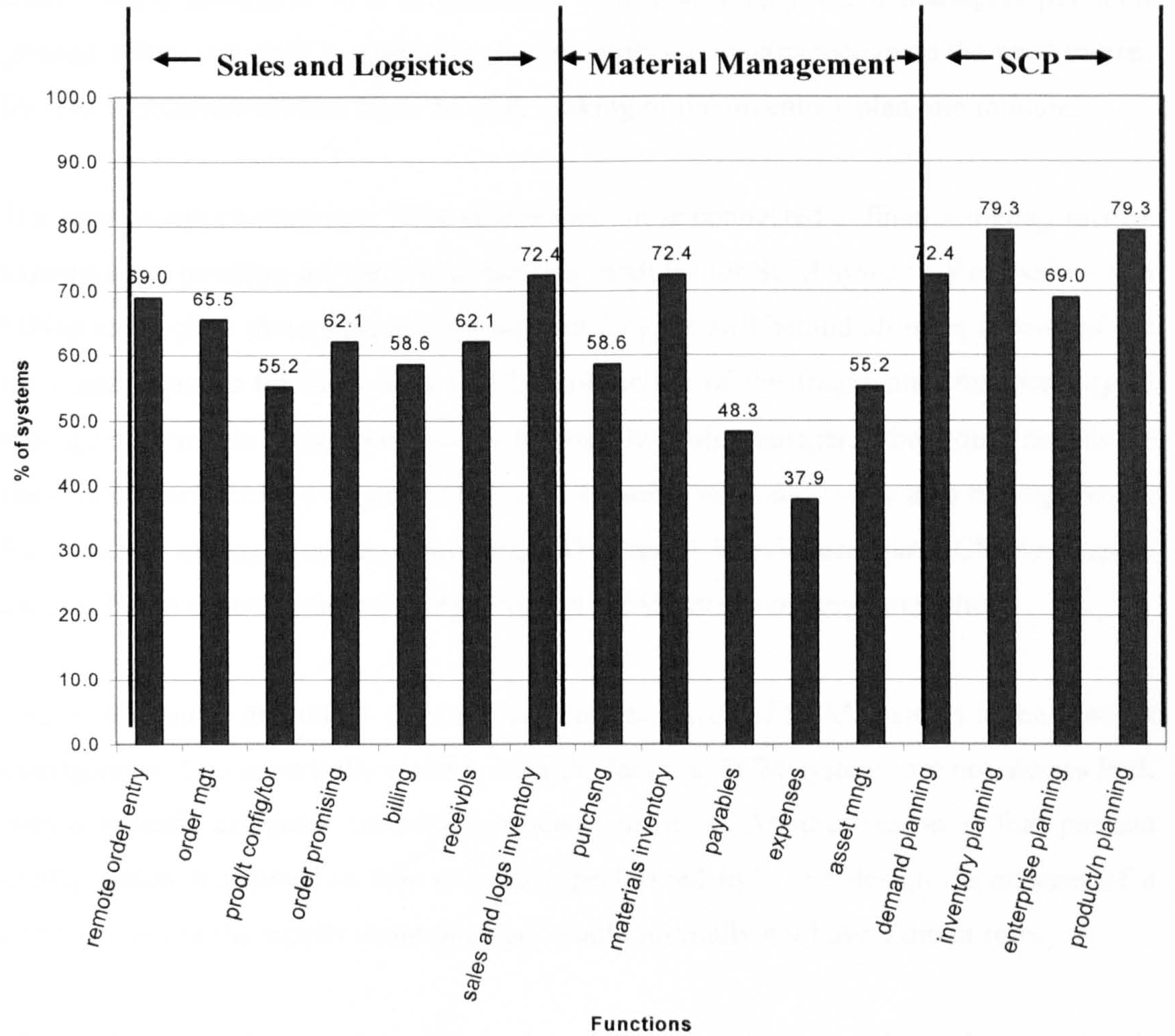


Figure 4.3. *FUNCTIONS OF SCM SYSTEMS*

Another important conclusion that can be derived from the analysis of the data is that inventory is considered to be a major issue for supply chain optimisation. Inventory ranks highest of all the functions for all the three areas of SCM that were studied: sales and logistics, materials management and supply chain planning.

Out of all the sales and logistics modules, which are popular in SCM systems, the most developed (and presumably the most important for users) is the sales and logistics inventory module. Managing inventories throughout the supply chain is the priority of supply chain managers. It is important to note that supply chain managers put their greatest efforts not only in managing the inventory - they also recognize the need to plan for it as it becomes evident from the high ranking of the inventory planning module.

The least popular modules of SCM systems are those connected to finance management – expenses and payables are the lowest ranking modules for SCM systems. Receivables and billing are slightly more popular modules but they are still behind all other aspects of the sales and logistics function. This fact is a reflection of the fragmented functionality of management within large companies – the supply chain manager, who would usually be the driving force behind implementing a SCM solution would rarely also be responsible for accounts management and payments. This result is evidence that SCM systems in general fail to achieve internal integration, let alone inter-company integration.

The least popular module in the sales and logistics area of SCM systems is the product configurator. This is partially a result from the fact that SCM systems are not always built with a specific company (and thus, product) in mind. Another reason is that product configuration is a function that is usually performed by/at the design department of a company where the supply chain manager would normally not have a direct role.

The order-promising module is an important link between the sales manager's commitments and the management and allocation of the company's production resource. Therefore, it is bound to have a crucial input in the SCM optimization process and consequently into the whole SCM system. With view of that, it is surprising that the module ranks lower than the order management module. A possible reason for this may be that the respondents to the survey questionnaire may have considered order promising as a part of the entire order management function.

Remote order entry is an important feature of every SCM system. This module has a crucial role for the real-time input of demand data into the SCM system and ensures that production and logistics planning works with relevant and up-to-date data. Therefore, it would be expected that remote order entry is an essential element of each SCM system. It is interesting to find out that 31% of all SCM systems do not have remote order entry functionality and therefore rely on data that is potentially outdated.

Out of all materials management modules, inventory management ranks highest – another opportunity to reiterate the importance of managing inventories throughout the supply chain. The purchasing module ranks much lower than inventory management – theoretically 13.8% of all SCM systems lack the functional opportunity to coordinate purchasing with inventory levels throughout the supply chain. This conclusion comes to prove once again that what is commonly known as SCM systems in general do not span functional and physical company borders in order to achieve the required optimisation of supply chain operations.

As much as asset management is important for ensuring that the production process has the required capacity to meet actual and potential demand, it is another surprising finding that as many as 44.8% of SCM systems do not have an asset management module. Supply chain optimization is impossible to achieve if the data about the asset availability and adequacy is missing from the supply chain picture that is input into the optimization engine. This is another reason to doubt that real optimisation is achievable by any of the currently existing SCM systems.

4.4.3 STRATEGIC AND VALUE CHAIN SCOPE OF THE SYSTEM

The next question asked the respondents to place their products on a map of SCM software, which positioned the software according to its strategic orientation and scope of coverage of Porter's value chain activities. The responses to this question helped to map the current status of development of SCM systems and spot the gaps in the coverage of today's systems. The responses are plotted on Figure 4.4. The graph shows what percentage of the respondents state that the system they offer assists in each of the areas comprising Porter's value chain.

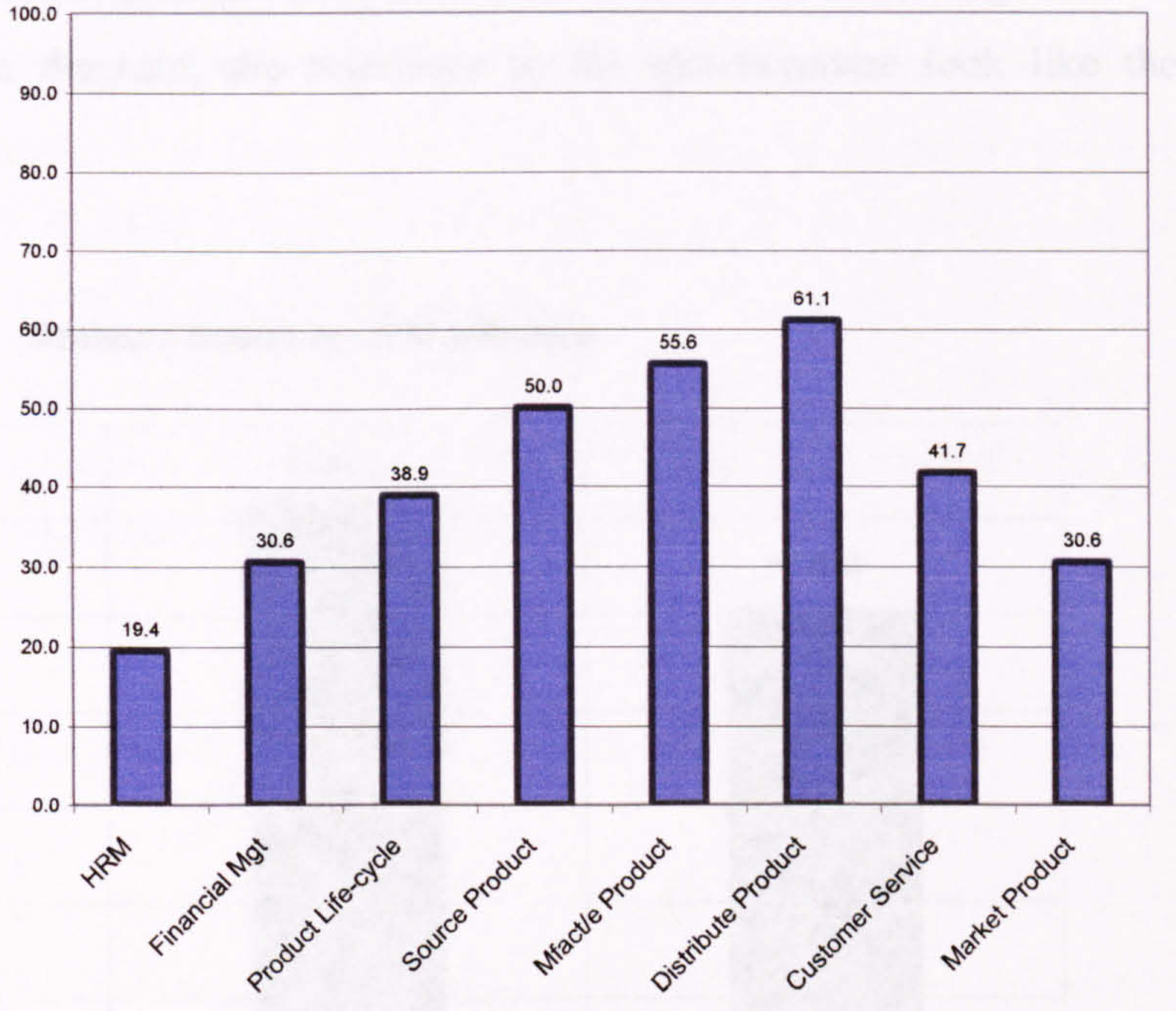


Figure 4.4. ***LOCATION OF SCM SYSTEMS ON PORTER'S VALUE CHAIN***

The most important conclusion from the analysis of the current section of the questionnaire is that SCM software vendors focus their attention on the Manufacturing and Distribution activities within the value chain. Other areas of the company's management are relatively less well covered. Surprisingly, support activities in the value chain are somehow not considered to be a part of SCM with HRM functionality of SCM software being present in just 19.4% of SCM software packages. Furthermore, while present, this module would only have a limited functionality in the majority of the software systems.

Only 5 of the total of 26 companies (19%) stated that their products cover all the areas of the value chain. This figure is indicative of how few the software solutions are, which are designed to help the user manage the entire supply chain. Further analysis is required to establish the validity of the statements in order to conclude that there are true SCM software solutions on the market.

The strategic scope of SCM software solutions also renders an interesting area of speculation. Plotted on a diagram, the responses to the questionnaire look like the diagram in Figure 4.5.

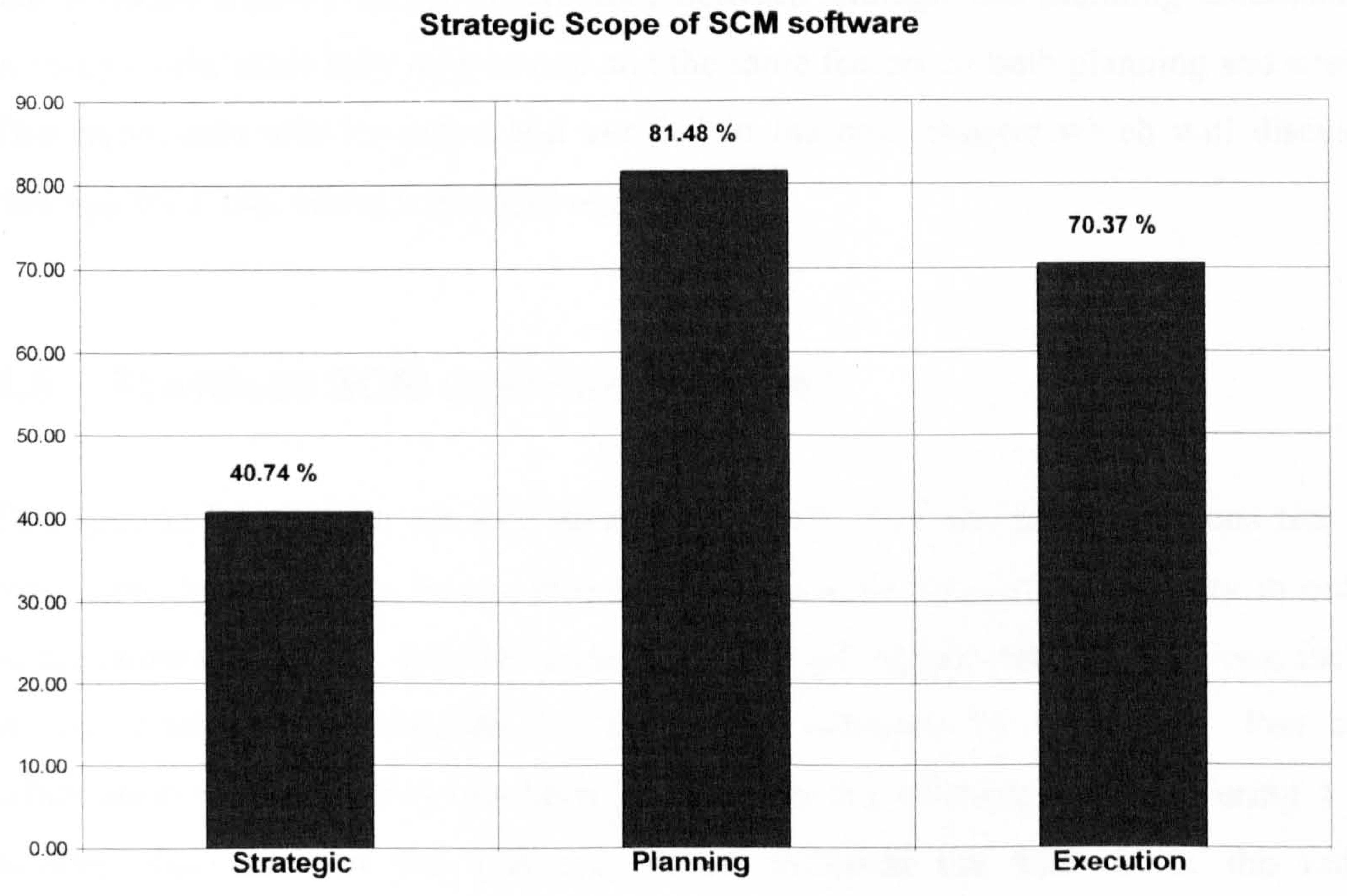


Figure 4.5. *STRATEGIC SCOPE OF SCM SOFTWARE*

The conclusion emerges that the majority of SCM software vendors consider their product to be mainly of a planning character. Execution functions are offered by 70.37 % of the software vendors. This is a reflection of some vendor's perception that a lot of well developed execution systems already exist and focusing on the development of execution functions would not give their product any competitive advantage. However, the viewpoint fails to acknowledge the importance of the competitive advantage that would be achieved by well-integrated planning and execution functionalities.

The strategic scope of SCM software solutions proves to be limited. Less than half of the software vendors would say that their product offers any strategic functionality. Furthermore, most respondents who call their products strategic do not really mean that.

The strategic functionality of SCM software should help the supply chain manager, who is using the software to develop a long-term strategic view of the supply chain and to help him optimise the strategic structure of the supply chain. In many of the cases, vendors stated that the solution offers strategic functionality without really meaning it, it seems that software vendors do not differentiate between strategic and planning functionality – in many of the cases they refer to one and the same feature as both planning and strategic. This hypothesis will be tested and verified in the next chapter which will discuss the findings from interviews with SCM experts.

4.5 FEATURED SCM SOFTWARE VENDORS

This section is going to provide more insight into 5 of the SCM solutions that were considered in the survey by questionnaire. The author found this necessary in order to demonstrate that a more detailed analysis of a sample of the software solutions, included in the survey, would validate the information collected by the survey. Part of the information in this section has been provided by the software vendors during a more detailed discussion of the software, which followed the analysis of the returned questionnaires. The above was complemented by research and the author's experience with the software operation. Each of the software features in this section comprises a detailed description of the software functions, as well as its strategic scope. Each software solution is on the SCM grid as a conclusion.

4.5.1 NAVISION (NAVISION AXAPTA, NAVISION ATTAIN)

Navision is a global provider of scalable integrated business solutions. Through a network of more than 2,400 accredited partners, it provides business solutions to over 136,000 customers in 30 countries. Navision follows a 100% indirect sales model: its current channel in the UK consists of over 80 accredited Navision Solutions Centres. Its product range consists of Navision Axapta, Navision Attain/Financials and Navision XAL, covering all business areas from financial management and CRM to manufacturing, logistics and e-commerce.

Navision Axapta is an international solution conforming to the market and legal requirements of individual countries. Users can run multiple languages within the same installation.

Navision recommend Navision Axapta as their SCM solution. It is for that reason that the description of the product will focus on Navision Axapta

Navision Axapta

Navision Axapta is an enterprise and e-business solution that includes integrated functionality for supply chain collaboration (including manufacturing and distribution), financial management, customer relationship management, HR management, business analytics, multi-language and multi-currency operation.

Navision Axapta is scalable, which means that it can be used from small to large organisations - it is available for up to 1,000 users. Depending on the user's needs, it can be deployed from any device at any time. This means that wherever data is sourced, Navision Axapta integrates it all into one workflow.

Navision Axapta was first installed in 1998 and as of 2000, it was operational in 60 UK sites. Axapta features the following functionalities: Real-time information reporting, B2B (Business To Business) transactions, B2C (Business To Customer) transactions, Web-based order & delivery tracking, E-procurement product catalogue, Action-based purchase or sale management.

In the SCM software survey questionnaire, Navision Axapta was claimed to have all the main functions in the following areas: ERP, SCP, SCE, APS, OMS, MES, WMS and basic functions in the area of TMS. Of all the modules which were listed in Section II.3. Modules of the System, only Expenses was absent. Therefore, judging from the vendor's statement, it can be concluded that Navision Axapta covers all the functional areas of the supply chain, namely: HR Management, Financial Management, Product Life-Cycle Management, Procurement, Manufacturing, Distribution, and Customer Service. What stops Navision Axapta from qualifying as a fully functional SCM tool is that all those functions are supported at only the execution and planning/tactical levels and no strategic functionality is inbuilt into the system. Navision Axapta also lacks support for marketing and sales staff, although it does have a Customer Relationship Management module (Figure 4.6).

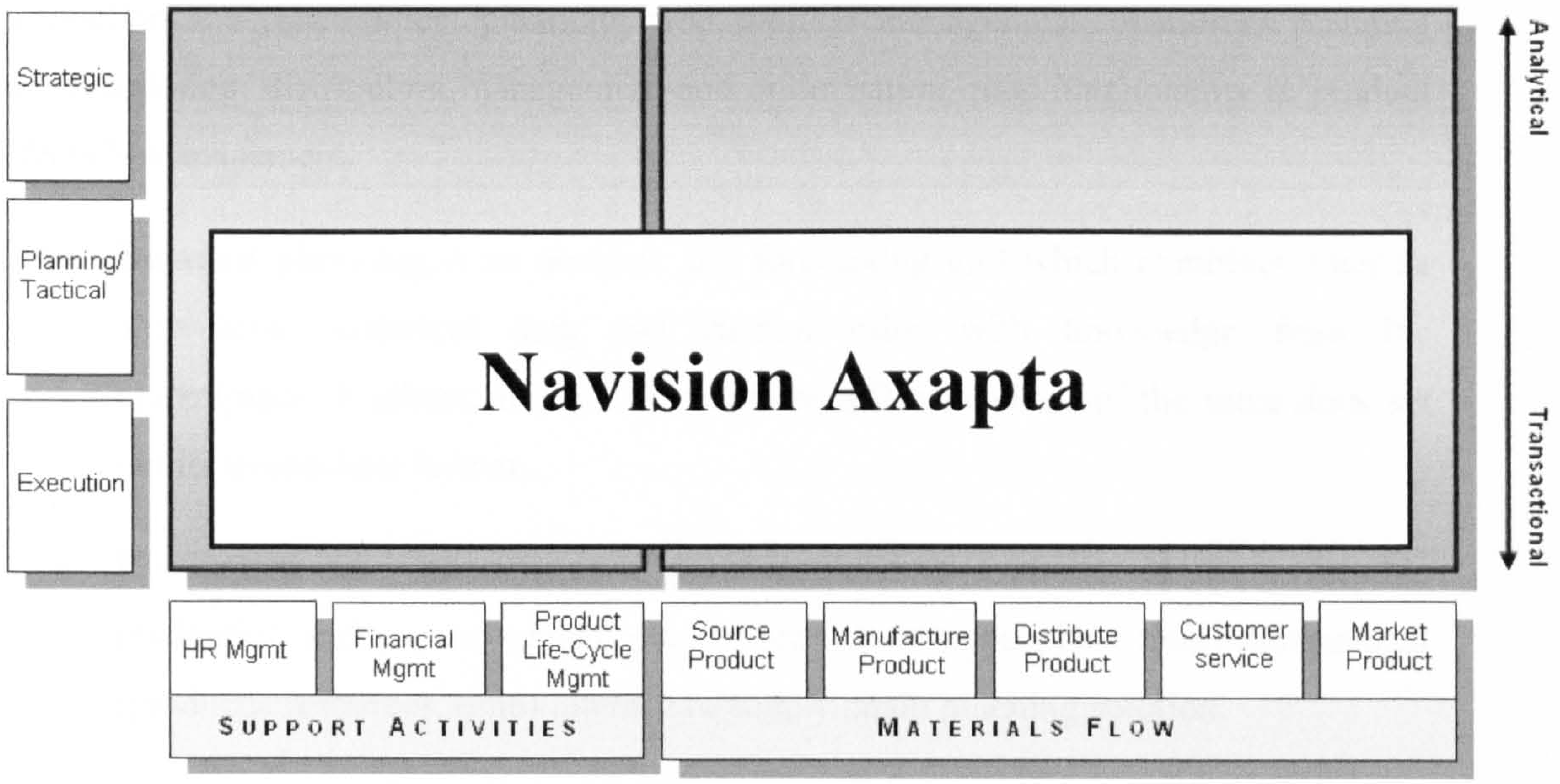


Figure 4.6. ***SCM SCOPE OF NAVISION AXAPTA***

4.5.2 TXT (TXT.SC&CM)

Founded in 1989, TXT focuses on enterprise applications – developing software solutions for the extended value chain, including the areas of supply chain and customer management.

It has 400 staff across Europe and is headquartered in Milan with offices in Turin, Genoa, Rome, Paris, Barcelona, Frankfurt, Berlin, Cambridge and London. An international 24 hours a day, 7 days a week help centre is run from Bari.

TXT solutions are recommended, installed and maintained through a network of accredited partners who provide training, consultancy and support before, during and after implementation.

TXT.SC&CM

TXT's SC&CM (Supply Chain & Customer Management) product suite covers demand planning and forecasting; web demand and web order management; assortment planning; production and procurement planning; web supplier management; operations planning and scheduling; distribution management and optimisation, plus functionality in product lifecycle management.

- **Demand planning** is an analysis and forecasting tool which combines forecast algorithms, historical data and current sales with knowledge from the marketplace. It allows multiple users to see different views of the same data, set out in spreadsheet format.

- **Production and procurement planning** allows users to derive a feasible production and/or procurement plan. It provides a multi-plant, multi-dimensional (products, resources, time) interactive supply chain planning solution.

- **Operations planning and scheduling** allows users to prepare improved, feasible production plans. Planners can use interactive graphical screens and traffic light warnings to save and compare different scenarios and simulate the effect of decisions.

- **Web supplier management** enables users to synchronise subcontractors and suppliers with the internal production, connected via a browser. Web order management covers and synchronises the order cycle and includes available-to-promise and capable-to-promise functionality.

- **Distribution management and optimisation** offers continuous replenishment inventory management. Users can determine stock level objectives for every distribution centre according to pre-defined restrictions.

In the SCM software survey questionnaire, TXT.SC&CM was described as an APS system. It also has all the main functions in the areas of SCP and SCE and some not fully developed features in the area of MES. TXT.SC&CM does not cater for the needs of operations, warehouse and transportation management. Of all the Sales and Logistics modules which were listed in Section II.3, it only provides functionality to enter orders from remote, product configurator and order promising. Entire order management, as well as billing, receivables and sales inventory are not supported. Materials management and the sub-modules in the group are not addressed at all, although the system enables the user to carry out planning in the following areas: Demand, Inventory, Production and Order Promising. Therefore, judging from the vendor's statement, it can be concluded that TXT.SC&CM does not cater for managing the whole supply chain and for carrying out all the important activities within it. Although it does provide some useful and well developed functionality, it cannot be considered to be a fully functional SCM tool. The system is inadequate in the vertical coverage of the supply chain, as depicted in the Diagram in Figure 4.1 – it has a very limited execution scope and does not attempt to deal with issues at the strategic level of SCM. (Figure 4.7).

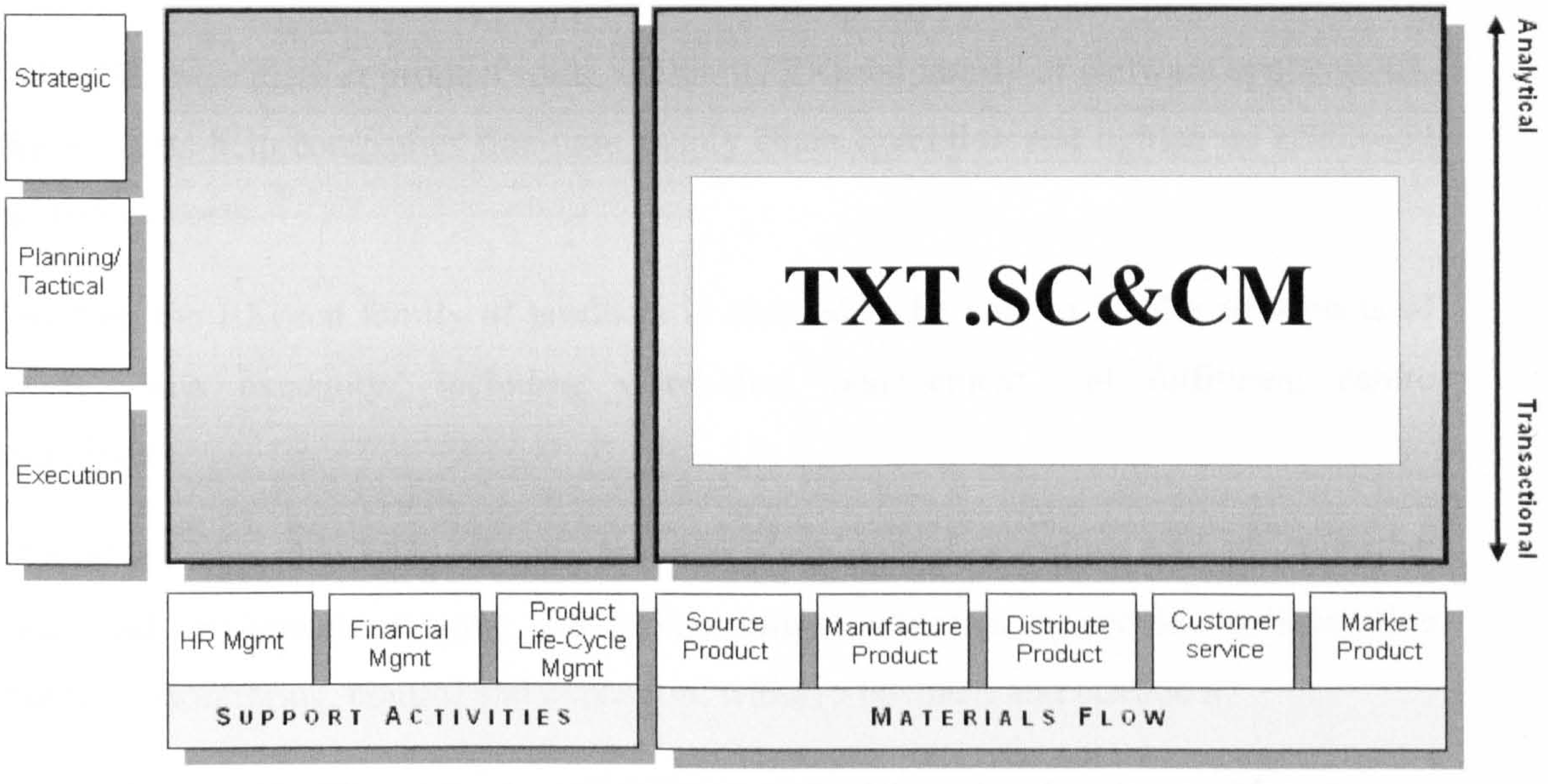


Figure 4.7. SCM SCOPE OF TXT.SC&CM

4.5.3 EXE TECHNOLOGIES (EXCEED)

EXE Technologies is a provider of supply chain execution software, working with companies and governments worldwide. EXE provides consultancy and support specialists, together with its EXceed family of supply chain software products.

EXE aims to offer a combination of global presence, financial strength and operational and technological expertise. It has over 20 years' experience and claims a track record of delivering improved business performance across organisations of all sizes.

EXceed is active in over 1,200 sites worldwide in a number of business verticals, including retail, wholesale, manufacturing, high-tech, automotive, military and third-party logistics.

EXceed

EXE offer three distinct product suites within its EXceed family of software applications. The products help companies fine-tune supply chain execution and tighten up efficiency and reduce costs.

Together, the EXceed family of products is claimed to be able to handle all aspects of supply chain execution, including warehouse management and fulfilment centre operations.

EXceed is designed to bridge the gap between planning and execution, with products that guide and implement planning and replenishment activities or provide collaborative visibility, monitoring, control and execution, within a business and outside it:

- **EXceed Fulfill** At the heart of EXceed Fulfill is the Warehouse Management System. EXceed WMS is suited to high-volume fulfilment, retail and wholesale operations as well as complex value-add areas such as 3PL and manufacturing. It is able to handle large numbers of discrete products, from order to shipping. EXceed WMS can be used on its own or with any of the complementary products in the range, including yard management, appointment scheduling and warehouse optimisation. It also offers a range of optional components, including crossdock, billing and kitting modules.

- **EXceed AIM – Adaptive Inventory Manager.** AIM is a demand forecasting, planning and replenishment system that helps retail and distribution organisations manage their inventory for higher profit. AIM links the planning, purchasing, merchandising and logistics operations of an organisation. AIM performs demand forecasting, purchase order generation, order sizing, product allocation and buyer review functions.

- **EXceed Collaborate.** Collaborate provides a detailed view of what is happening in the user's supply chain and enables the user to take corrective action where required. The system is process modelled to business requirements, its features include granular visibility, key performance measures, exception reporting and system control of the supply network. Collaborate is non-invasive, meaning that it will work with existing enterprise systems.

In the SCM software survey questionnaire, Exceed was claimed to have all the functions which are attributable to SCP, SCE and WMS systems. However, it cannot be classified as either ERP, APS, OMS, MES or TMS system. The Sales and Logistics modules that it features are related to transaction processing (i.e. billing, receivables, and inventory status) but do not offer more advanced and dynamic features such as remote order entry, product configurator, order management or order promising. The Materials management module, on the other hand, provides purchasing and inventory management functionality but do not relate those activities to payables, expenses, neither does it enable asset management. Supply Chain Planning, within EXcced, covers the areas of Demand and Inventory Planning. Production and Enterprise Planning are not included in the functionality of the system.

The conclusion from the review of the answers to the supply chain management questionnaire is that Exceed has a very limited scope along the horizontal dimensions of the Diagram in Figure 4.1 – overall, it is a Warehousing Management tool with some functionality in Distribution and Inventory Management. It fails to address huge areas of the supply chain such as Manufacturing, Sourcing, Marketing and CRM, as well as some support activities such as Human Resource Management and Product Life-Cycle Management. Although EXceed does provide some useful and well developed functionality, it cannot be considered to be a fully functional SCM tool. The system is inadequate in the vertical coverage of the supply chain as well – it covers extensively the execution level and links it successfully (as claimed by EXE Technologies) to the planning level but no attempt has been made in the area of strategic SCM. (Figure 4.8).

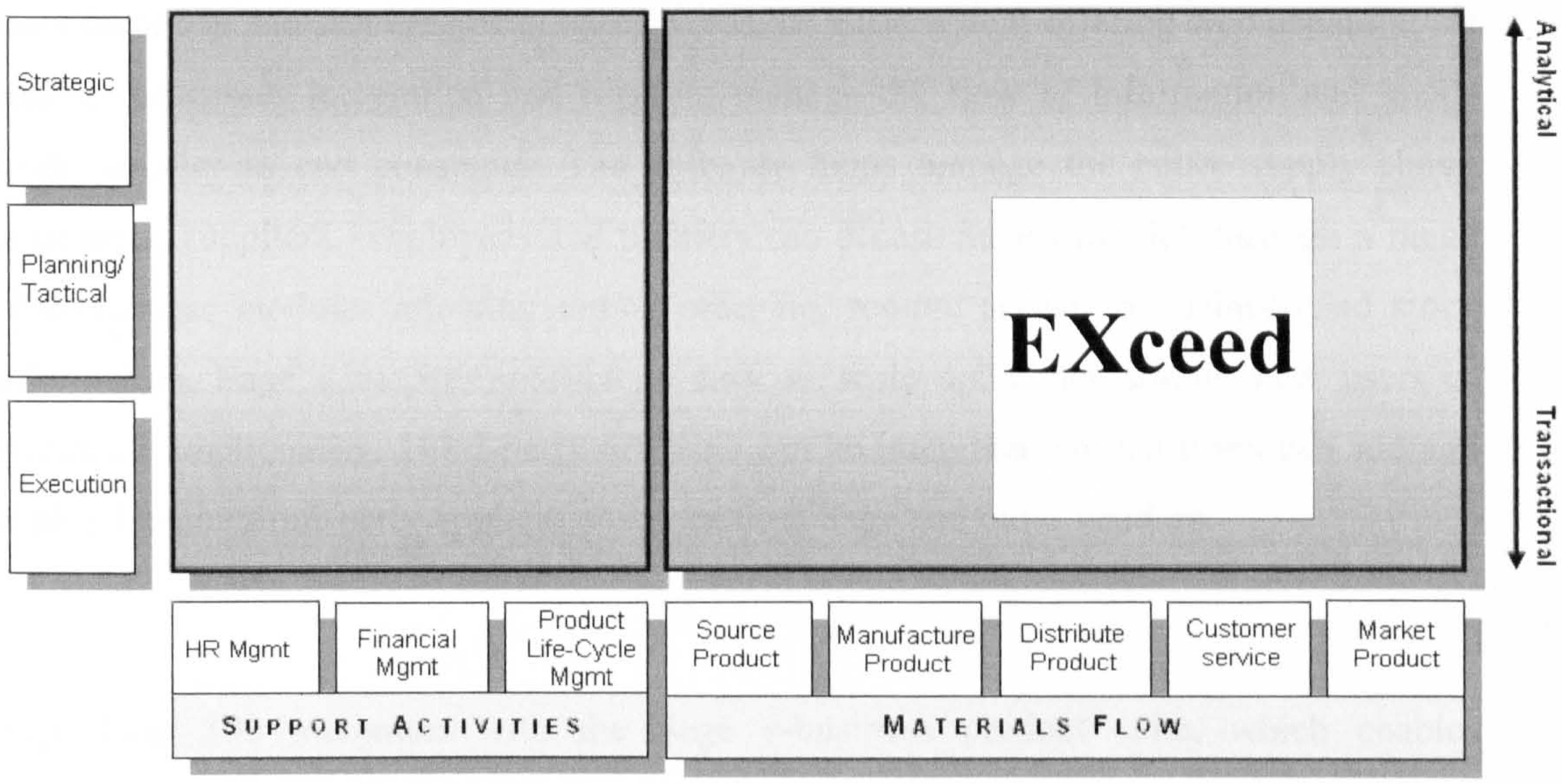


Figure 4.8. SCM scope of EXceed

4.5.4 SAGE (SAGE LINE 500)

Founded in 1981, Sage has grown to become one of the global market leaders in the business software market with over 3 million customers around the world.

Sage offers a broad range of solutions, from entry-level products for start-up businesses through to more sophisticated solutions for larger businesses. With solutions that range from four to over 1,000 users, Sage's Enterprise customers are wide-ranging in size and turnover. They include Tulip, Dorlux, Autotrader, WorldPay, RPC Cresstale, Duracell, Eurocoin and Time Computers.

Sage states that its Enterprise solutions can support businesses across all industry sectors, including manufacturing, construction, engineering, distribution, government and media.

Sage Line 500

Sage's software solution for mid-range and larger organisations is Sage Line 500. It is an integrated and web-enabled business management system covering finance, distribution, manufacturing and services, or in other words, an ERP system offering web capability. It enables processes integration and helps to manage the flow of information and goods from supplier to end consumer. The software helps manage the entire supply chain: customers, suppliers, employees and partners can access Sage Line 500 through a range of e-business modules allowing online ordering, remote access to business and stock information. Sage Line 500 solution is easy to scale up, either adding new users or increased functionality. Third-party products can be integrated so that users can add and deploy leading third-party applications from both Sage and other vendors.

Sage Line 500 integrates with the Sage e-business product suite, which enables companies to extend their business online without incurring major expenditure. Integration between front-office and back-office systems ensures that the enterprise system works as a unified entity. Web technology also offers the choice of secure remote access for mobile employees and partners.

In the SCM software survey questionnaire, Sage Line 500 was claimed to have all the functions required from a modern SCM system. The only area, in which the software is not claimed to be fully developed, is MES. The system features comprehensive functionality in all the main areas of SCM: Distribution, Manufacturing, Services, Finance and e-Business. The core modules in the Distribution section are: Inventory

Control, Sales Order Entry, Sales Invoicing and Analysis, and Purchase Order Processing. The Manufacturing section includes Bill of Materials, Works Order Processing, and Material Requirements Planning modules. The Services section provides functionality through Project Ledger, Project Billing, Resource Ledger, and Contract Management. The core modules in the Finance section are General Ledger, Accounts Payable, Accounts Receivable, and Cash Management. E-Business modules include Web Sales, Web Client, Web Portal, EDI Interfaces, and XML Interfaces.

A major drawback of the system is the limited help it can offer to strategic decision-making. Although it is a very well tried and tested, highly developed ERP system, like all ERP systems, it caters for the execution and planning levels of SCM but does not provide strategic vision into the supply chain. (Figure 4.9)

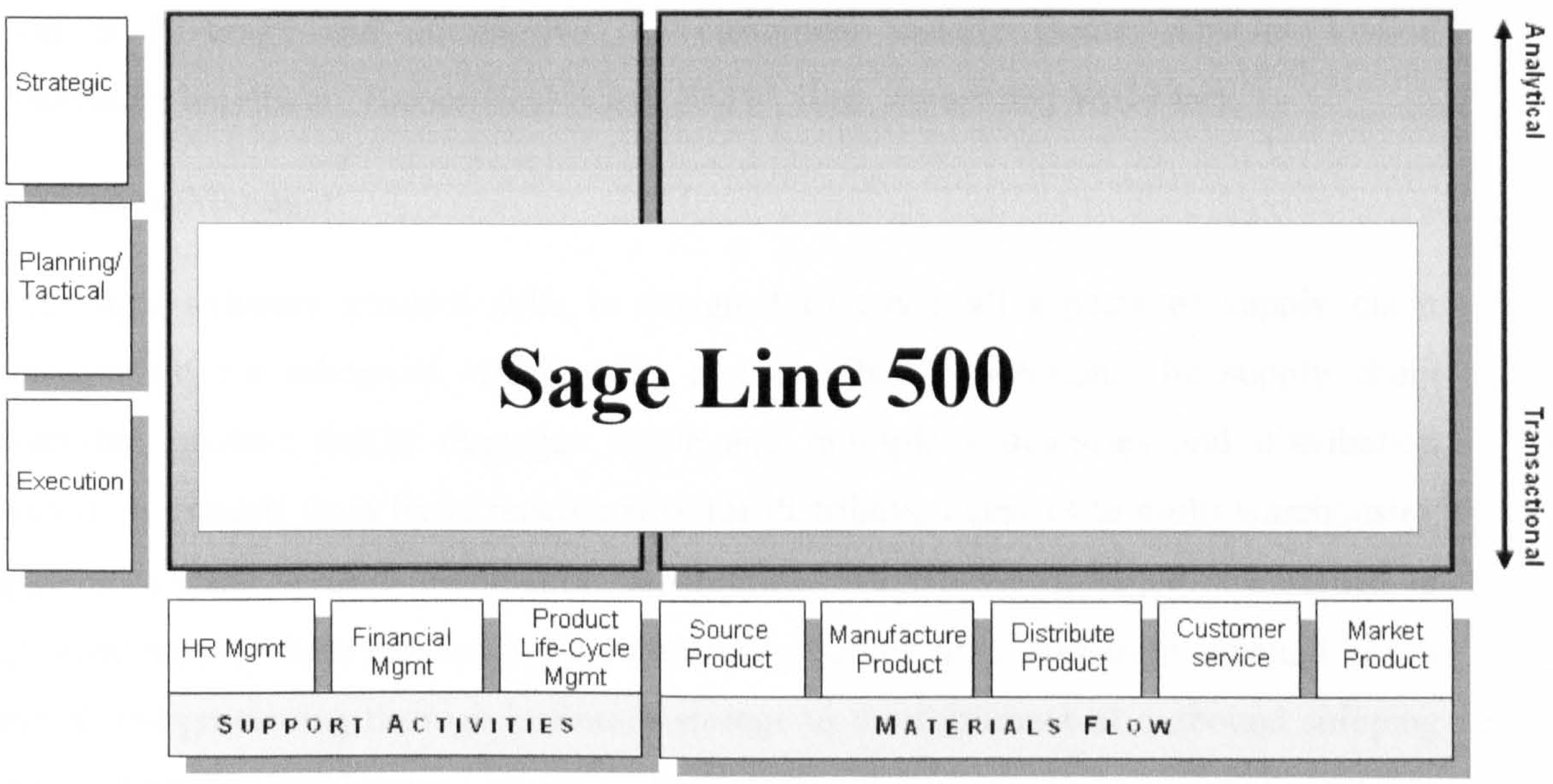


Figure 4.9. ***SCM SCOPE OF SAGE LINE 500***

4.5.5 SWISSLOG (WAREHOUSEMANAGER)

Swisslog is a global provider of integrated supply chain execution solutions that cover the value creation process, from procurement and production to delivery.

Swisslog's history dates back to Sprecher & Schuh AG, founded in 1898. Since then, Swisslog has evolved from a supplier of automation systems, to a global provider of consulting services, the implementation of integrated logistics solutions, supply chain software packages and support and maintenance. It has years of experience in the development and implementation of integrated logistics solutions, with customers in more than 50 countries.

Swisslog has experience in many industry sectors including distribution, pharmaceuticals, food & beverage and automotive. Its customers include Boots, Absolut Vodka, Boehringer Ingelheim, Baxter Healthcare, BMW, Ikea, Jaguar and Wal-Mart.

WarehouseManager

Swisslog's software product suite is designed to cover all aspects of supply chain management for advanced warehousing and distribution solutions. Its supply chain execution product family manages single and multiple warehouses and distribution centres. It extends from basic functionality for distribution centres to multi-warehousing applications and broader automation capabilities. **WarehouseManager** is designed to optimise supply chain efficiency by automating the key processes from inbound goods arrival and processing through inventory storage to the fulfilment of outbound shipping orders. **AutomationManager** integrates the automated equipment of a logistics plant into a single transport system, providing the optimum throughput under any system load. **VoiceManager** offers speaker-independent voice-controlled operation of warehouse management systems, leaving the hands and eyes of operatives free for their work actions. The suite also includes **WarehouseCockpit**, a monitoring product consisting of several modules that help users keep their operations running at peak performance. **EventManager** is a system monitoring and control tool. It supervises all applications, resources, servers and connections that the Swisslog warehouse solution uses. **KPI**

monitor – in combination with EventManager alerts warehouse operators in case of bottlenecks or shortages. **WarehouseMonitor** is a graphical web-enabled tool for monitoring and controlling various activities within a WarehouseManager environment, including order/dock status and labour productivity. **ResourceMonitor** is a modelling tool for evaluating labour shortages by zones in order to meet the picking requirements for outstanding orders and to re-assess the movement of labour resources and its impact. **AutomationVisualizer** enhances AutomationManager with an animated display of any logistics plant. The dynamic plant visualisation and centralised alarm handling provides instant error indication. **BillingManager** enables users, especially 3PL service providers, to define services and associated charges for invoicing. The products fit seamlessly with the automated solutions that Swisslog provides.

Warehouse Manager is a software tool which is clearly not aimed at covering the whole range of SCM activities. Instead, it focuses on a single area of SCM and attempts to provide all the necessary functions and features to manage it. Although the respondent to the survey questionnaire defined the product suite as being a SCE system, it is clear from the wide range of modules that it has a far greater focus than taking an execution-only view on the warehousing activities. The suite provides modelling and optimization features which unquestionably provide a deeper insight in the strategic formation of the supply chain. Therefore, the author is confident in saying that Warehouse Manager attempts to take a strategic view of SCM and provide support for strategic decision-making (Figure 4.10). An important observation from the review of WarehouseManager is that a software solution which only caters for one area of SCM is often seen (and promoted) as a SCM tool.

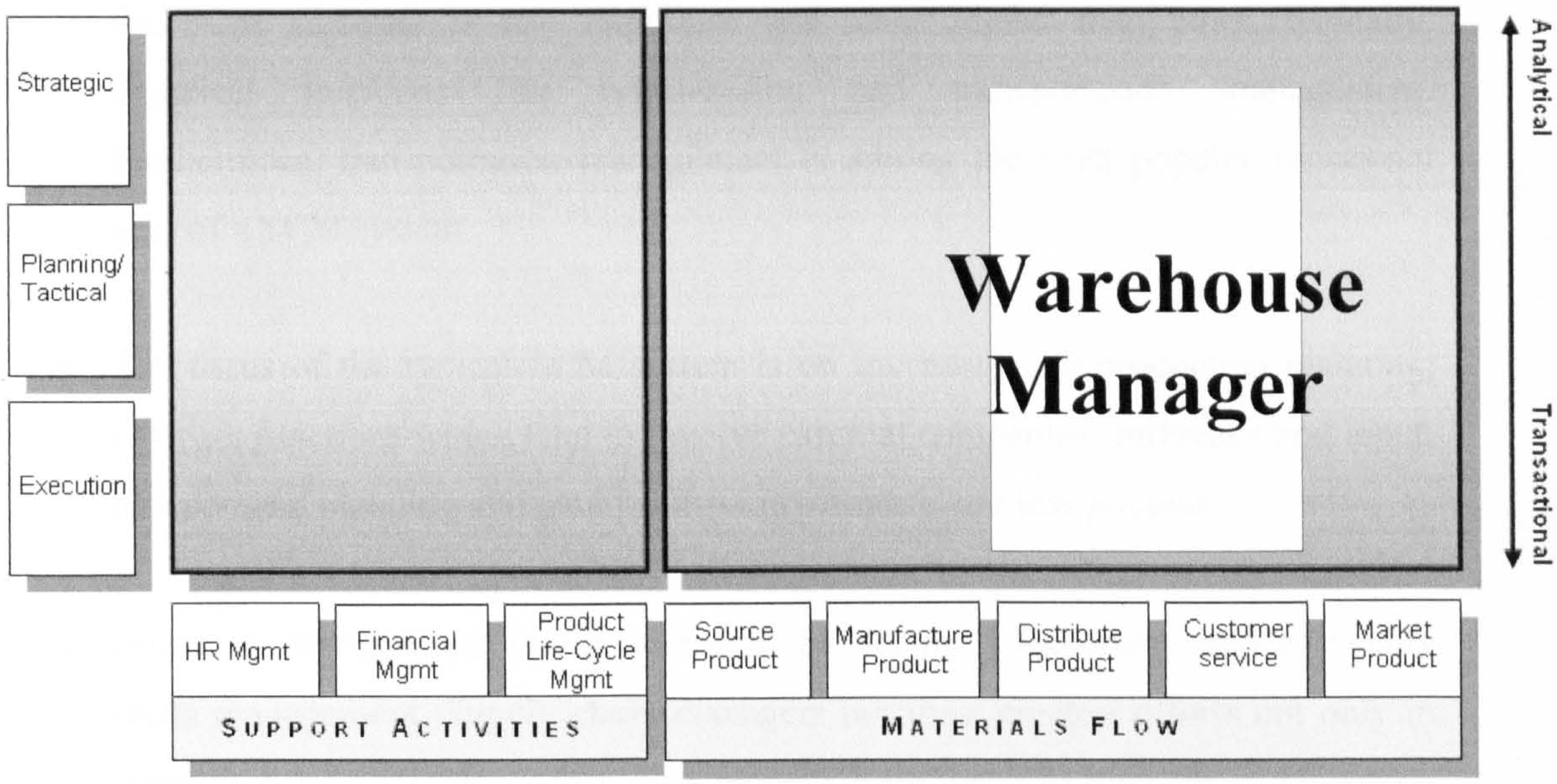


Figure 4.10. ***SCM SCOPE OF WAREHOUSE MANAGER***

4.6 CONCLUSIONS

In summary of the discussions in the present chapter, it must be stated that the software survey helped draw the following conclusions:

- Most commonly, SCM software vendors call their system an "Advanced Planning and Scheduling System" (APS). Although APS involves both planning and scheduling (execution), software vendors give preference to the execution function of their products.

- A lot of software vendors use the terms ERP and SCM interchangeably. There is confusion among software vendors as to what the differences and similarities between the two types of system are. Generally, this follows from the fact that there is a lack of common agreement on the definition of a SCM system.

- SCM systems pay attention to optimising the entire value chain rather than just the manufacturing part of it. However, the manufacturing execution function of the SCM software is still important and ranks higher than other, typically, logistical functions like warehousing and transportation management. Furthermore, transportation management is among the least popular functional area of a SCM system.

- The focus of the typical SCM system is on inventory and production planning, whereas functions which tend to involve external companies' influence and input, like demand planning and enterprise-wide planning, are less popular.

- Inventory management is considered to be the most important area of supply chain management. Supply chain managers put their greatest efforts not only in managing the inventory - they also recognize the need to plan for it. However, 13.8% of all SCM systems lack the functional opportunity to coordinate purchasing with inventory levels throughout the supply chain due to the absence of a purchasing management module.

- The least developed modules of SCM systems are those connected to finance management and they are among the most commonly omitted modules in a SCM suite.

- The least popular module in the sales and logistics area of SCM systems is the product configurator. 31% of all SCM systems do not have remote order entry functionality and therefore rely on data that is potentially outdated.

- 44.8% of SCM systems do not have an asset management module, which would ensure asset availability and adequacy.

CHAPTER 5 – SURVEY BY EXPERT INTERVIEWS

5.1 INTRODUCTION

This chapter discusses a series of interviews with supply chain management experts (SCME) and presents the findings that resulted from the research.

The main purpose of conducting a survey by expert interviews was, as explained in the chapter on methodology, to verify the results and conclusions from the survey by questionnaire and to minimise the bias of the conclusions which was expected to result from the marketing and promotional efforts on the part of the respondents to the SCM questionnaire.

For the purposes of the current chapter and the dissertation, the term "supply chain management expert" will be used to describe the following job categories:

1) a professional employee involved in the operation and management of either the whole supply chain or any significant part of it (such as purchasing, production, distribution, logistics management);

2) a consultant (either self-employed or working for a consultancy organisation) whose expertise is in either SCM in general or any specific functional area within the supply chain, including expertise in advising and supervising the implementation and usage of SCM software;

3) an IT expert involved in the implementation, operation or maintenance of a software system which is known on the market to offer supply chain management functionality;

4) a scholar undertaking research, lecturing or participating in an industrial project in the area of SCM.

As the list above suggests, the interviewers were conducted with people from a variety of background, with different levels of experience in SCM software applications. The resulting breadth of views was on one hand, challenging to analyse and put together in the form of conclusions, but on the other, offered an extensive input into the research and was invaluable for the high credibility of the results. Altogether, 31 SCME were interviewed. Of them, 7 were consultants (such as Rod Moulding, who is also the chairman of the Institute of Operations Management's APS SIG), 9 were SCM practitioners (for example, Paul Flanagan, Supply Chain Director at ADAMS), 6 were IT experts (for example, Ian Scarr, Solutions Architect at Fourth Shift), and 9 were scholars (such as Dick Back, Department of Logistics and Transport, University of Huddersfield).

The researcher undertook the survey by expert interviews to improve her understanding of the way in which supply chain experts view today's supply chains, how they are managed, as well as to study their expectations for future trends in the developments of SCM and the software associated with it. The interviews spanned over the full 3 years' duration of the research project and the majority of them were ongoing activities, rather than having the form of a one-off meeting for the sole purpose an interview. A variation of the interview method was the slightly different approach of collecting information about the experts' views by studying their behaviour and practices, thus gaining a different point of view. By observations, rather than interviews, the researcher gained a more immediate idea of what the reality is, as compared to gaining an idea of what supply chain managers think the reality should be.

The observation and interviewing process was guided by a questionnaire, listing points of interest which were to be discussed with the experts. The questionnaire was created for guidance only and was not intended to restrict the areas of discussion. It was aimed at keeping the focus of both the interviewer and the interviewee on the relevant issues, in case the discussion took a different direction. Appendix 5.1 presents a list of the main topics that were discussed and the questions which were attempted to be answered. The questionnaire consists of three sections – introduction to the interview, discussion topics and concluding remarks. The introduction was intended to acquaint the interviewee with the purpose of the interview and what it was hoping to achieve. An official introduction was only necessary in the cases when the interview was a one-off event and the participant was an expert or a supply chain manager who was not familiar with the research project. However, in many instances, an introduction was not necessary because the experts who were being interviewed (or observed) were involved in other parts of the project, or in other projects which were running in parallel with the main one. Wherever an introduction was appropriate, it was carried out by the interviewer and consisted of an approximately 5-minute presentation which brought out the benefits of studying the current status of development of SCM and the software tools used for SCM.

The discussion topics during the interviews can broadly be placed into three main categories: questions about SCM in general (what SCM is and what SCM software systems are supposed to do); questions about a particular SCM system (one that the SCM expert was familiar with), and questions about the expert's view on the future trends in the development of SCM and SCM software.

Questions about SCM in general included discussion topics such as the relation between APS, ERP and SCM, and what areas and activities are included in SCM from the expert's perspective. The discussions under this section attempted to clarify the expert's personal understanding of what SCM is and had a dual purpose – firstly, to draw a conclusion of what experts in SCM and supply chain managers think SCM is; and secondly, to make sure that the expert is in the "right frame of mind", i.e. is prepared to discuss the supply chain as defined for the purposes of the research.

If the SCM expert had no direct experience in working with a SCM software tool, in most cases he or she had observations on other users' experience with such systems or had supervised or consulted a company utilising a SCM system. The experience of such experts, although indirect, was extremely valuable for the reliability of the survey results because their views were taken into consideration when drawing the conclusions from the interviews. In a couple of the cases, when the experts were not familiar with a particular SCM system or had not been involved in any way with such a system, it was interesting to discuss their idea of what a computerised automated solution should be able to do in order to assist them in their day-to-day activities. Such discussions helped to raise fresh views, and develop some innovative ideas, which had not been considered previously by SCM software developers.

All the interviewees were given the opportunity to express their views on the future development of SCM, and SCM software in particular, during the third section of the discussion. The experts were encouraged to think not only in terms of additional functionality of the software but also in terms of broadening the scope of what SCM tools are intended to deal with. This means that the experts were asked to think not only about functions directly related to SCM activities, but also about responsibilities that may not be directly within the scope of their job whereby the availability of information as well as compatibility with other typical SCM functions would be of benefit for their decision making.

In closing the interview the SCM experts were thanked for their cooperation and assured that their views would be kept confidential and their identity would remain undisclosed. This latter point was made clear at the beginning of the interview in order to make sure that the interviewees feel at ease to share their personal experience and views of the discussed topics. In many cases, revealing the identity of the interviewed SCM experts would make it unavoidable to associate them with a particular manufacturing or consultancy company which would greatly restrict their freedom in expressing their personal opinion. It was expected that, by working with a particular software solution (or representing it), the SCM expert would have become familiar with its major deficiencies and therefore the SCM expert would feel more inclined to discuss its disadvantages and even to criticise the implementation as a whole, if he or she is assured of privacy and his or her view would be disclosed as anonymous. That is why it was decided to withhold the identities of the participating SCM experts and to represent a summary of their opinions, rather than separate reports from each of the interviews.

5.2 SCME FINDINGS

The findings of the expert interviews and observations are summarised below. The researcher decided to document all the thoughts and opinions concerning SCM and not only those directly related to SCM software. The reason for doing that is that the historical development of SCM software shows that developments in SCM software follow directly from the most recent developments in the SCM theory. Besides that, the author found some of the conclusions very interesting and thus well worth documenting in order to serve as a starting point for further research into the future development of supply chain management tools and methods.

5.2.1 TRENDS IN THE DEVELOPMENT OF SCM

Today's supply chain managers recognise the fact that today's businesses face competitive pressure to deliver new products and services at lower cost and to bring new offerings to market rapidly. Because of advances in manufacturing and distribution, the cost of developing new products and services is dropping, and time to market is speeding up. This has resulted in increasing customer demands, local and global competition, and increased pressure on the supply chain.

The general conclusion of the SCME was that to stay competitive, companies must reinvent themselves so that the supply chain - sourcing and procurement, production scheduling, order fulfilment, inventory management, and customer care - is no longer a cost-based back-office exercise, but rather a flexible operation designed to effectively address today's challenges.

The Internet is proving an effective tool in transforming supply chains across all industries. Suppliers, distributors, manufacturers, and resellers now work together more closely and effectively than ever. Today's technology-driven supply chain enables customers to manage their own buying experiences, increases coordination and connectivity among supply partners, and helps reduce operating costs for every company in the chain.

In the past, assets were a crucial component of success in supply-chain management. In today's market, however, SCME are of the strong opinion that a customer-centric orientation is key to retaining competitive advantage. There are several points which they suggest should be considered when creating a successful, customer-centric supply chain:

- Taking orders is only one part of serving customer needs. Businesses must fulfil the promise they make to customers by delivering products and information upon request - not when it's convenient for the company to do so.

- Time to market is a key competitive advantage. Companies must ensure uninterrupted supply, and information about customer demands and activities is essential to this requirement.

- Cost is an important factor. Companies need to squeeze the costs from internal processes in order to make the final products less expensive.

- Reducing design-cycle times is critical, as this allows companies to get their products out more quickly to meet customer demand and competition.

Developing and implementing a networked, flexible supply chain that integrates all partners - manufacturers, retailers, suppliers, carriers, and vendors - into a seamless unit is the first step in meeting customer demand and maintaining a competitive edge. Taking this step is crucial for companies that seek to make better real-time forecasting decisions, reduce their inventory and associated costs, and speed the delivery of products and services. In doing so, companies transform their supply chain from a cost-based back-office exercise into a flexible operation designed to effectively address today's challenges.

According to SCME the evolution of a networked supply chain involves the following steps:

- Sharing static or dynamic information, including inventory levels, schedules, forecasts, and design documents, among companies and partners by integrating the Web with back-end systems such as enterprise resource planning (ERP)

- Conducting transactions, including exchanging purchase orders, invoices, shipping information, and so on, through a network such as the Internet or a virtual private network (VPN)

- Establishing business communities, such as portals, Web marketplaces, and auctions and bidding communities, to let business processes evolve and to further integrate companies.

Through these changes, companies and their partners can see themselves as a single virtual organization. Shipping becomes on-demand and just-in-time, and the payment cycle is streamlined. As a result, companies change both how they conduct business and how quickly customers receive products from suppliers.

By implementing a networked and integrated supply-chain management system, companies can reduce costs, increase revenues, improve service, speed their products' time to market, and use their assets more effectively.

The SCME were unanimous that innovative companies that implement supply-chain management techniques are realizing a number of key benefits, including:

- Cost reductions in inventory management, transportation and warehousing, and packaging

- Enhanced customer satisfaction through online order entry and configuration
- Improved service through techniques such as time-based delivery and make-to-order
- Enhanced revenues, thanks to higher product availability and greater product customization
- Reduced product-cycle times
- Increased market share due to shorter engineering-to-production cycle times
- Flexibility to design, market, and retire products more rapidly
- Ability to sustain product quality while outsourcing major portions of the fulfilment process

Supply chain management experts acknowledge the role of a few events in the development of technology and SCM thinking that have contributed to the recent upsurge in the way companies manage their supply chains. The following developments were mentioned at different stages of the survey during expert interviews.

Radio-Controlled Supply Chains

SCME report that the bar code has performed admirably during the more than three decades since its inception, but a technology called radio-frequency identification (RFID) is gathering momentum and experts are adamant that it will replace the bar code in many supply-chain applications. RFID uses radio waves to automatically identify goods in the supply chain, such as pallets, containers, and even individual items. Once the tag readers capture the RFID data, they route it to software such as inventory-management and supply-chain event-management applications. When integrated with the information networks of manufacturers, suppliers, distributors, and retailers, the information RFID provides increases visibility and efficiency up and down the supply chain.

Global Supply Links

SCME report that global communications and transportation networks have improved dramatically in the past 20 years, linking distant businesses and trading partners. Companies have jumped into international markets, outsourced their manufacturing operations, and established supplier partnerships around the globe. As a result, supply chains now routinely extend across multiple countries and regions.

The Internet plays an important role in this expansion. It is accelerating the process of globalization as people worldwide research products on the Web, buy and sell on e-commerce sites, and manage international supply chains with collaborative software and portals. At the same time, it is also the best tool available for coping with the new complexities of managing international supply chains, including sourcing, transportation, trade compliance rules, communications, and international finance.

The Networked Virtual Organization

SCME have observed on many occasions that successful companies have adopted a Networked Virtual Organization (NVO) model - in which an organization teams with two or more external organizations, all connected by a common network infrastructure, to bring a new product or service to market. The NVO model fosters agility and efficiency by prescribing the adoption of enabling technologies to increase organisational competitiveness. The three essential principles Of NVO include customer focus, continuous standardization, and core versus context.

An NVO business model provides a company with the flexibility to mitigate risk in uncertain business environments because it allows the company to respond more rapidly to changing market demands. NVO companies are flexible because they have the capability to reduce their cost structures by engaging other companies in their virtual systems to develop new products or services or to outsource activities that no longer add value.

Web-Based Sourcing

Large corporations usually buy thousands of unique parts and materials from a huge base of suppliers and that is why identifying the most reliable suppliers and negotiating contracts is clearly an immense challenge. Web-based sourcing, a category of applications that use the Internet to improve the way corporations source materials, has emerged over the past two years. Web-based sourcing helps companies not only during, but prior to procurement as well and comprises a variety of technology applications, including the following:

- analytics tools that help companies evaluate spending, bids, and strategy
- negotiation tools that handle various formats, such as requests for information, requests for quotes, reverse auctions, and multilined bids based on a bill of materials (BOM)
- collaboration tools that help define specifications among internal and external stakeholders
- document- and knowledge-management tools that help track the large volume of sourcing documents, including parts data, BOMs, design drawings, schematics, and change requests, while maintaining a single authoritative source of information
- project-management and workflow tools that handle role-based access to sourcing information, document routing, and other related tasks

Cost reduction is the most obvious benefit of Web-based sourcing. Web-based sourcing tools help organizations aggregate their collective spending power and use it to negotiate better prices from suppliers. Web-based sourcing tools also save time by cutting workflow and streamlining the exchange of huge volumes of documents between one buyer and multiple suppliers. Saving time and money is important, but companies must also weigh elements including quality, delivery times, volume, and supplier flexibility. The most advanced tools for web-sourcing incorporate all those factors into their decision-support matrix.

Supplier Portals

A supplier portal is a web-based technology that allows suppliers to self-author their catalogues and to approve or reject submitted catalogues or content. Here, the suppliers would be able to find all the tools and services required to author their content in a web-friendly environment. Once items are processed in the supplier portal, the full suite of software functions, including importing electronic files, editing and modifying items, and appending and deleting data is available for information management through the entire product life cycle.

A supplier portal includes seven major categories of business processes, according to AMR research. They are: product development / engineering, sourcing, supply chain collaboration, supply chain execution, settlement, quality management, and performance management.

Supplier portals allow companies in a supply chain to use the Web to increase visibility, streamline operations, and reduce costs for manufacturers and suppliers alike. The ability to update information about forecasting, scheduling, and pricing in one central location allows constituents up and down the supply chain to make adjustments and react more efficiently to inevitable changes.

Supplier portals offer a number of compelling benefits. Supplier portals can save time and money by automating basic transactions, such as purchase orders, advance shipment notices, invoices, and advance receipt settlements. The biggest benefit of having a supplier portal is that by providing direct access to process participants, it reduces the time an organization must spend updating information both internally and with the supplier, which ultimately enables an expedited process flow. Portals can play an important role in improving supply-chain visibility. Suppliers can help manage a buyer's inventory if they can access current stock-level information. Buyers can also help suppliers by sharing demand forecasts online.

SCME predict that, as companies extend their use of portals, they will become a key enabler of the global supply chain.

E-Manufacturing

The foundation for e-manufacturing is based on a pull system in which products are made to order, thereby allowing companies to customize their offerings to meet specific demands. Companies can manufacture their products more efficiently by moving away from building work-in-process and finished goods in excess of actual demand, thanks to the creation of virtual factories and the trend toward smaller facilities with little storage space.

E-manufacturing requires an up-to-date manufacturing execution system, complete with data acquisition, analysis, and decision-support software. Such systems create the flexibility to respond with the right number of resources to meet demand fluctuations. Embracing e-manufacturing forces organizations to accept the necessity of short lead times and zero inventories, and e-manufacturing is an ideal way to meet the demand of an increasingly customer-driven world marketplace. SCME indicate that an increasing number of companies are adding this to their operations.

5.2.2 SUPPLIER RELATIONSHIPS

The respondents in the survey were unanimous about the fact that it is very important that each company manages the relationships with all the participants in its supply chain as well as possible, as this can result in better supply chain performance, improved manufacturing and product and process advancements. These in turn will enhance customer satisfaction and company performance. Companies should effectively select and evaluate their supply chain partners and manage their involvement in the supply chain in order to achieve better customer satisfaction through more competitive pricing, better product quality, wider variety of products and better delivery service.

The following points were highlighted by various participants in the survey by expert interviews:

- Availability from suppliers is an important consideration as poor availability from suppliers will result in poor customer satisfaction and will affect the profitability of a business.

- Sometimes poor relationships with the suppliers could stem from factors internal to the company such as unrealistic promotions set by the marketing department.

- Difficulties associated with staff could either comprise of problems associated with training people on the shop floor on how to use the systems or problems associated with unwillingness of people to change. It was concluded that people are a very important factor and usually they are the ones that cause problems. In order to manage them in a more successful way it is crucial to make them understand the reasons for change. The concept of SCM in itself requires people to change by adopting new ideas and ways of doing things.

- The time issue is equally important when managing both software suppliers and materials suppliers. One of the participants in the survey highlighted the importance of not rushing decision-making saying that "we have waited and it has paid off for us".

- It is very important to have realistic expectations from your suppliers and to be aware of their delivery capabilities.

- Involvement of suppliers and collaboration with them in the supply chain should be actively encouraged.

- Suppliers should be treated with respect. Always putting suppliers in a stressful position (e.g. pressing them for price reductions, hinting that if they don't meet requirements, they will be substituted) does not contribute to a healthy atmosphere of cooperation and might cause them to keep things "up their sleeves" and behaving unethically.

- Mutual understanding and trust are very important factors for developing and maintaining good relationships with the suppliers.

- The issue of contracting was discussed. The views ranged from the need for "robust contracting" to the idea that "the value of the contract is zero".

- An interesting point outlining the significance of managing supplier relationships was made. It focused on the need to arrange those relationships in advance by saying that "we didn't have the relationships, we were fixing the mistakes instead".

- The issue of e-commerce was discussed. E-commerce is seen as an "enhancement" driving the transaction costs down. It also allows for speeding up of the processes and is perceived as a cost effective transaction tool.

5.2.3 RELATIONSHIPS WITH SOFTWARE SUPPLIERS

The relationships with software vendors are as important and as complex as those with materials suppliers. Decisions about IT are seen as crucial to business as failure to deliver an IT system can have a critical effect on an organisation's ability to provide services to its customers. Therefore, decisions on IT projects are not just of technical nature, but they are rather business decisions and senior management should be involved in taking such decisions. IT projects fail at different stages - from conception through implementation and the responsibility lies both with vendors and users.

The participants in the survey raised the following issues:

- Relationships with software suppliers were defined by one of the interviewees as "horrible". The reason for dissatisfaction is that software suppliers often heavily affect the implementation process by pushing the business systems through what they envisage or are able to offer. A point was made that software vendors do not listen to user's views.

- The importance of a high-quality specification clearly outlining the user's requirements was highlighted. It was pointed out that the principle is the same whatever the product is: give the software vendors a high quality specification and be sure that they have in-depth understanding of your business.

- 'Niche markets' are what suppliers should be looking for. They should adopt the so-called 'modular' approach to developing software. This opinion was objected by a few other participants, namely those representing bigger companies, who stated that what they would like to have is a complete solution and not a patchwork of solutions offered by various suppliers which often causes issues of compatibility and difficult integration. The different views show that the 'best-of-breed' versus 'one system fits all' debate continues.

- It is very important to understand what the company obtains for the money paid. Sometimes internal IT people do not understand the benefit. Clear specifications and simple explanations would be appreciated by all companies looking at purchasing and implementing SCM software.

- It is up to the user to put much more effort into the different stages of an IT project. "Could the reason [for the failure of an IT project] be that we do not know our own business"? That is why, it is essential to know the company's business systems, and how they work from the beginning to the end. This could be achieved by process mapping before implementing the software. This is a time-consuming process but, according to the attendees, it is worth spending the time on it.

- The issue of cost/budget justification - before starting an IT project ask whether the project is justified or not. This would involve a detailed cost and benefit analysis whereby the participation of the potential software supplier is essential.

- Training is an essential part of an IT project, sometimes more important than the implementation itself. Training of staff is expensive and takes time, but is essential for the overall success of the project.

- The user is often oversold – what you get is not proportional to what you pay for. That is why you have to check your processes and get appropriate decisions on what you buy and what you pay for.

- Have a time plan and plan for regular reviews whereby the plan could be changed if this is justified. Take time to sit back and review the progress of the project itself – consider whether the delay is caused by a generic fault with the project or is it a necessary adjustment which would benefit the successful outcome.

- The power should be with the buyer and not with the software vendor. The vendor should be there to serve the buyer's objectives.

- It is essential to understand and properly manage the risks associated with the IT projects.

- During the negotiating process, document assumptions. Do not just rely on verbal communication.

- ROI payments versus paying up front were recommended. The former is difficult to negotiate and adopt as a strategy as it is difficult to prove and measure results

5.2.4 SUPPLY CHAIN MANAGEMENT SOFTWARE

When asked to define Supply Chain Management (SCM) systems, SCME described them as back-end applications designed to link suppliers, manufacturers, distributors, and resellers in a cohesive production and distribution network and thus allow an enterprise to track and streamline the flow of materials and data through the process of manufacturing and distribution to customers. SCM applications represent a significant evolution from previous enterprise planning systems, such as MRP, in terms of their ability to integrate an enterprise's business partners into the production process. By enabling greater data sharing between these supply chain partners, SCM applications improve production efficiency and flexibility. SCME outline the three primary goals of an SCM system as:

1. Reduction in inventory costs by matching production to demand. SCM forecasting applications utilise extremely complex planning algorithms to predict demand based upon information stored in the company database. These applications also incorporate any changes in supply chain data into the forecast much faster than previous modes of calculation, allowing companies to more accurately predict demand patterns and schedule production accordingly.

2. The lowering of overall production and logistics costs by streamlining the flow of goods through the production process and by improving information flow between an enterprise, its suppliers, and its distributors. Logistics-oriented systems such as transportation management, warehouse management, and factory scheduling applications all contribute to reduced production costs. By ensuring real-time connectivity between

the various parties in a supply chain, these applications decrease idle time, reduce the need to store inventory, and prevent bottlenecks in the production process.

3. Improved customer satisfaction by offering increased responsiveness and adaptability. SCM applications allow enterprises to reduce lead times, increase quality, and offer greater customization, enhancing the customer relationship and improving retention. The SCM process begins with forecasting and data mining applications analysing information consolidated in the enterprise's database to establish requirements and then meets these requirements quickly and effectively through streamlined processes.

Supply Chain Management represents the convergence of all facets of the manufacturing and sales process: anticipated demand, production and storage capacity, capital resources, time constraints, and profitability objectives. The value proposition of an SCM application is the capacity to integrate suppliers, manufacturers, and distributors into a dynamic Internet-, intranet-, or extranet-enabled system that takes all of these factors into account. Through the increased collaboration between supply chain partners permitted by such a system, an enterprise effectively extends its operational boundaries. Suppliers are better able to anticipate the enterprise's need for materials, the enterprise is better able to schedule production processes and manage inventory levels, transportation companies are better able to coordinate material delivery and product distribution, and customers are better able to place and track orders.

The way that SCME see SCM software corresponds to the way SCM systems were defined for the purposes of the research project. It is important that the way in which SCME view the supply chain is as an entity of enterprises which are unified by the common goal to achieve the desired customer service levels most efficiently and effectively. The conclusions also suggest that SCME do not view SCM software as simply transactional and reporting tools but also as decision support and optimization tools. This is a key issue because it, arguably, differentiates SCM software from ERP.

SCME view the market for supply chain solutions as a case of too much demand chasing too few effective solutions offered. In addition to the enormous challenges associated with integrating web-based back-end applications with legacy mainframe and client/server systems, SCM adopters face the difficult task of linking their systems with those of their supply chain partners. Internal IT divisions rarely have either the staff or the technical knowledge to deal with this level of complexity.

Linking a Supply Chain Management system to an enterprise's legacy ERP applications and other internal systems is only the first step in a long and complex process. The bulk of the implementation work occurs beyond the boundaries of the enterprise and involves the integration of the SCM application with the systems of an enterprise's supply chain partners: raw materials and component suppliers, distributors, and shippers. Full integration involves linking incompatible and non-communicative software, hardware, and infrastructure systems. This connectivity increases collaboration in the forecasting, purchasing, production, and inventory management processes, and in synchronising delivery and distribution schedules.

The difficulties associated with this task can be exacerbated depending on the financial condition, level of technical sophistication, and overall mindset of the supply chain partner. Partners constrained by financial, technological and cultural considerations can complicate integration immensely. Increasingly, SCM adopters will require the services of specialized integration partners who have the technical knowledge and experience to effectively surmount these and other obstacles.

As adoption of SCM systems accelerates, customers are increasingly demanding both Supply Chain Planning and Supply Chain Execution functionality in their back-end systems. These demands have led to a disconnect between the solutions desired by the marketplace and the solutions that vendors are capable of providing; although certain SCP vendors are beginning to branch into SCE applications, the supply chain market is far from fielding a unified SCM suite encompassing both planning and execution.

In addition, there is a lack of complete functionality even within the SCE segment, as the major vendors have yet to offer a fully functional execution suite spanning inventory, warehouse, and transportation management, as shown in the previous chapter. In order to bridge the gap between the functionality desired and the functionality available, enterprises often purchase from multiple supply chain software vendors. With the introduction of the first comprehensive

SCM suite several years out, SCME expect demand for integration services to remain strong for the near- to medium term.

The supply chain functionality required by a given enterprise varies widely across vertical markets. Discrete manufacturing demands different production optimization techniques than process manufacturing, and inventories of consumer goods cannot be managed in the same manner as inventories of industrial components. As the SCM market matures, it will mirror the CRM market in that applications will become increasingly specialized along vertical industry lines, leading to increased demand for vertically focused service providers.

SCME believe that a growing number of SCM-related consulting and integration contracts will be awarded based on vertical market experience and that private services companies that move quickly to establish themselves within a set of vertical markets will have a distinct advantage over their competitors.

SOURCING AND SUPPLIER RELATIONSHIP MANAGEMENT SOFTWARE

SCME report that most of the sourcing solutions are focused at the online negotiation process. Very few of them walk the purchasing manager through the entire process of selecting the suppliers, classifying them on the basis on not only purchasing price but other important factors as well. The type of information they are looking for, varies widely depending on the industrial category and the company, and the particular purchase. Such information could be delivery time, past quality performance, payment terms, location, ability to service multiple locations, proximity to manufacturing facilities, and breadth of assortment. Therefore, procurement tools can be divided into two groups – those addressing sourcing and those supporting strategic sourcing. When asked to compare sourcing and strategic sourcing, most experts say sourcing is about price, and strategic sourcing is about understanding the total cost of procurement, the impact all those variables have on the ultimate price that the company pays to source the required material.

The problem of today's strategic sourcing, supply chain management experts report, is that those companies who do it, do it entirely manually. They either use spreadsheets and their own people, or they bring in consultants when they need to. The problem with using spreadsheets is that the user has to build weighting models to score each of the suppliers to see who has the best overall deal. Where there are more than 20 suppliers to be assessed, it could take three to six weeks to build the spreadsheet to do the analysis.

SCME are of the opinion that with any enterprise-class piece of software there is a fair amount of customization that has to be done. However, across different verticals, there is not much difference in terms of the way that companies source. They follow the same main steps, almost no matter what business they are in.

Whereas the core of the product does not change much from industry to industry and implementation to implementation, one of the areas where it does change is the integration point. Procurement management software, for example, is a product that can work either on its own, or can be integrated with lots of other systems to make it even more powerful.

SCME think that sourcing management software has been slow to take off because the technology is very difficult. E-procurement basically automates what paper used to do. Sourcing, on the other hand, automates the way people do their job and the way that they make decisions. Therefore, sourcing is a much more complicated set of technologies. It incorporates functions such as multi-attribute, decision-support algorithms; Web application architecture; intelligent agent software design.

SCME expect that, in the next five to ten years, procurement software will make more use of the Internet because of the communication protocols and the ability it gives companies to talk to each other and do business with one another seamlessly, without having to get involved in complex integration.

WAREHOUSE MANAGEMENT SYSTEMS (WMS)

With customer service goals driving most facility operations, it is becoming increasingly important to have efficient process management systems that not only optimise the originating point of any raw materials and/or finished goods, but also are flexible enough to meet the diverse needs of the consumer at the destination point. A WMS with an efficiently designed materials handling component meets these quantity demands, but also allows for a variety of distribution techniques. The operations system develops the baseline from which the firm can determine how a specific facility will receive, store, pick, handle, and even transport the product to its destination.

SCME define a successful WMS as one that should help meet the significant growth objectives of fulfilment operations by increasing accuracy and reducing labour costs and cycle times, helping to manage the supply chain from production to consumer. The bottom line is that a WMS helps to get the most productivity from an operation and fulfil consumer demand. An ideal WMS contains enough flexibility to manage different categories of the distribution chain, from facility product flow to automated picking, put-away, or replenishment. On another level, an ideal WMS is flexible enough to successfully integrate into existing facility designs.

SCME report that most obstacles in WMS implementation are tied to the facility design itself. Successful product distribution and supply chain cannot rest solely on the logic of an operating system; the facility must be modern and efficient enough to allow for rapid system integration. If the facility layout is inefficient, the performance of the system is already compromised, potentially increasing the cost to get packages out the door - a heavy and avoidable capital loss due to unsuccessful WMS fit to facility configurations. The reverse applies as well, since a facility upgrade with its WMS carelessly modified to match the changes will only increase labour and production time.

5.2.5 INTERNET TECHNOLOGIES

SCME report that Internet usage appears to be in an early phase of adoption by the industrial world. Basic email interaction seems common between both suppliers and customers, while the proportion of suppliers taking orders on line is surprisingly low. The gathering of information about customers and suppliers, that is, corporate research, is also lower than would be expected.

There is a very close relationship between the adoption of cross company Supply Chain Management practices and Internet usage. Automatic replenishment processes and demand management (forecasting and planning) processes are positively impacted by use of the Internet. Interacting with customers through the Internet also impacts on customer satisfaction with on-time delivery performance.

In regard to interacting with suppliers, what comes through very strongly from SCME's opinion is that Internet usage strongly impacts supplier management of a customer's inventory in all supplier related digital technology areas. The sharing of planning and scheduling information with suppliers and electronic ordering capabilities are also positively impacted by Internet usage.

SCME suggest that a participant in a supply chain can benefit more from extending outward to their customers than back toward their suppliers. Customers appear to be more satisfied with on-time delivery performance when information is made available or provided through the Internet. In addition, SCME suggest that when the provided customer information is part of the demand management and the planning and scheduling processes, supply chain performance is improved. With the more frequent interaction enabled by the Internet, the Supply Chain Management processes run more smoothly.

SCME strongly suggest that Internet usage will enable companies to extend outward to suppliers to share forecasting, planning, and scheduling information. This sharing of predictions can significantly reduce inventory held just in case and increase the confidence in suppliers' commitments. This leads to less inventory and improved synchronization of supply chain activities. Also strongly suggested was that connection strategies such as vendor managed inventory are aided by the use of the Internet. This would further improve the synchronization of a supply chain's activities.

It is clear that company-to-company supply chains have begun to interact with their partners using the Internet. They share data, exchange emails, provide timely digital orders and some have begun to establish a collaborative effort with their partners. As organizations realise the benefits of supply chain partner collaboration, these organisations will no longer view themselves as a separate entity, but will view themselves as a partner of their supply chain network or business web. This integration of supply chain partners will better position them to fulfil the new customer demands requiring increased agility, versatility, and synchronisation of the Supply Chain Management processes.

5.3 PROBLEMS OF CURRENT SUPPLY CHAIN MANAGEMENT SYSTEMS

SCME experts are of the opinion that companies that adopted SCM into their operations strategies obtained mixed blessings. On the positive side were the improved communication, long-term relationships with suppliers, better flow of goods and information, reduced time span in the channel, and more grasp of the strategic issues. The downside of SCM adoption can be seen in the form of adversarial relations between suppliers and purchasers along the channel.

As a system that is made of several components which interact with each other by ways of communications, the supply chain is a strand of companies whose vulnerability and efficiency can be mainly measured by the reliability of the communication links. All types of failures can be seen in supply chain failures: it can be a process failure, correspondence failure, or interaction failure. While the nature of failures can be complicated and made of several components (social, managerial, or organizational), SCME argue that this can be controlled and minimized so as to foresee the severity of potential failures.

The experience of supply chain adopters highlights a number of challenging issues in this area:

- Problems usually result not from technology issues. In most of the cases, the cause of the problem is not which technology was chosen, but the need to develop a collaborative mindset that allows the organisation to demonstrate levels of trust in others and that accepts that partners can perform the competency better than they can.

- SCM is about thinking ahead and not fire fighting. Moving to a planned, exception management environment means that reacting and fire fighting are replaced, whenever possible, by planning and pre-emptive problem avoidance. This requires new skill sets and performance measures.

- There is a critical problem in deciding how the benefits of participation in a supply chain are going to be shared amongst the contributing parties. Pushing cost up or down the chain is not the way to achieve long-term success.

- Key business partners should be involved in the design of the supply chain – thereby securing commitment and starting the collaboration mindset. It is sometimes difficult for other, non-founding companies to join in without subjecting the design of the supply chain to criticism and to abide wholeheartedly by the established rules.

- Creating a single consistent view of information and content across multiple entities places high demands on the quality and accuracy of the base data. Although the majority of the companies operate an ERP environment, the availability of accurate high-quality data is still surprisingly challenging to achieve.

5.4 SUMMARY AND CONCLUSIONS

The process of interviewing supply chain management experts resulted in drawing a number of important conclusions which confirmed some of the ideas presented in the previous chapters. SCME confirmed that the supply chain market is far from offering a unified SCM suite encompassing both planning and execution. In addition, there is a lack of complete functionality even within the SCE segment, as the major vendors have yet to offer a fully functional execution suite spanning inventory, warehouse, and transportation management.

Supply chain management experts report that most of the point solutions focus on execution and fail to recognise that a further and more careful analysis is needed of other factors which contribute to decision-making. For example, sourcing solutions are focused on the online negotiation piece and very few of them walk the purchasing manager through the entire process of selecting the suppliers, classifying them on the basis on not only purchasing price but other important factors as well.

SCME reported that a major problem in SCM software applications is the issue of integration – both with existing software systems, and integration between the various supply chain management functions.

The interviews with SCME helped establish a clear vision of their idea of the future development of supply chains. The key features and functions of a future world-class supply chain will be:

- It will consist of a number of organisations each with a role to play, from brand owners, product designers, contract manufacturers, through to co-packers and other virtual service providers which, when combined, provide the solution sought by the customer.
- It will enable close and deep collaboration with customers, suppliers and service providers.
- It will make a single consistent set of information visible across the whole supply web –that is, inventories, committed orders and forward production schedules.
- It will provide close to real-time information, with a blurring of the distinction between planning and execution systems.
- It will enable companies to make future commitments, not only 'available to promise' but also 'capable to promise', with online availability, configuration and pricing that takes account of all parties within the web.
- The traditional gap between supply chain, customer relationship management (CRM) and supplier relationship management (SRM) and the incorporation of the value chain will disappear.
- Solutions that are web-enabled will be available to facilitate speed and ease of connectivity, e-market capable if and when required.
- Decisions will be based on automated and intelligent exception management.
- Companies can attain profit optimisation whilst ensuring continuity of supply.

The development of such an advanced world-class supply chain is dependent on the adoption of a new set of guiding principles for the design of processes, organisations and technology. Those principles are as follows:

- **Connectivity**. Its goal will be to create open collaborative supply web processes, organisation and technology.

- **Mindset and trust.** Organisations will need unprecedented levels of trust, sharing information and depending on other organisations to fulfil customers' requirements. Companies will go so far as to allow their partners to re-plan their operations.

- **Data and content.** To be able to operate in the supply chain environment, companies will require a common language. To achieve this, the ability to translate data standards and content into commonly understood formats is vital.

- **Information.** This will replace inventory as the key resource to ensure continuity of supply.

- **Systems.** Companies will need to be able to use the internet for connectivity and be able to optimise the supply chain seamlessly across organisational boundaries and legacy environments. This puts a mission-critical emphasis on those systems that extend beyond the enterprise.

The core features of the solutions which enable the application of the principles of the advanced supply chain include:

- Item-level demand planning, sales forecasting and demand management.

- Replenishment and supply planning.

- Collaborative planning, forecasting and replenishment with key trading partners for critical product categories.

- Supplier relationship management.

- Order management and fulfilment.

- Real-time dynamic scheduling of materials and production.

- Transportation planning, scheduling and management in collaboration with third parties.

- Network design and optimisation.

Supply chain management solutions use the data from ERP systems to help organisations make more intelligent and timely decisions – with full visibility and understanding of the impact of these supply chain decisions across different entities, both within and external to their enterprise. The issue becomes one of decision support across an extensive multipartner network to provide a currently unavailable level of optimization.

CHAPTER 6 – CASE STUDIES

6.1 INTRODUCTION

The chapter discusses the three case studies which were undertaken during the research process. The chapter starts with the justification of the choice of case study technique, building upon the discussion in Chapter 3 – Research Methodology. Following this, the three research case studies are described in detail. Each case study looks at a part of the supply chain of three companies of different sizes, from different industries and in different financial situations. Given the limitations imposed by the time available for the case study research, an attempt was made to focus on a different part of the supply chain at each one of the companies, rather than looking into the entire supply chains of all the companies. Another reason why this was necessary was the limited contacts available within the case study companies and even more so at other companies participating in the same supply chain. This is a fundamental problem in SCM research.

As discussed in Chapter 3, the case studies were intended to study the supply chain processes of several industrial companies of various sizes, coming from different industries to examine the way they manage their supply chains. The purpose of carrying out the case studies was to identify and review the tools and methods which those companies use to aid the SCM process. The benefits from including the case studies in the research were expected to be as follows:

- Enhanced industrial experience - the case studies would provide the researcher with experience in "real-world" supply chain management, and the processes and practices of managing both small and world-wide supply chains.

- Access to a variety of companies in terms of size, industry, supply chain management, general management policies and practices, and usage of supply chain management tools and methods.

- Validation – the case studies would help to achieve the research objectives of the dissertation and to answer the research questions.

- Action learning – the researcher would have the opportunity to consult the company and see her ideas implemented and taking effect. She would also have the basis for developing models and tools for improved supply chain management, taking into account users' feedback and requirements.

- Access to experts in supply chain management – during the case studies, the researcher would have the opportunity to talk to supply chain managers and other experts in the various parts and functional divisions of the supply chain. This would support the research by expert interviews (Chapter 5).

Each case study investigates current practices in the case companies and discusses how the companies, on the basis of their real and pressing needs at that point in time, identified the need for supply chain management tools and methods. The approaches taken, the results obtained and, where appropriate, the project implications are mentioned in each case study following the problem identification. A summary is provided at the end of each case study. The main issues identified from the three case studies, which led to the need for an improved tool for supply chain management are also discussed.

The way in which the case studies were carried out would best be described as participatory action research.

> "Participatory action research is the way groups of people can organise the conditions under which they can learn from their own experiences and make this experience accessible to others." [McTaggart, 1991]

During a participatory research process, changes happen throughout the entire research process. According to Wadworth, a hallmark of a genuine participatory action research process is that it may change shape and focus over time as participants focus and refocus their misunderstandings about what is really happening and what is really important to their research [Wadworth, 1998]

The choice of this particular type of case study approach was necessary because simple observational and descriptive approach would be of limited benefit for the collaborating company, and this would have made the availability of contacts and resources even more limited. Undertaking action research would also provide opportunities for basing the development of a specification of an improved supply chain management tool on findings from implemented improvements to the practices of the case study companies.

Contact for the first company was through a Research Fellow, employed by the University and based on working on a full time basis at the company. Contact for the second case study was through an MSc student who was completing a degree in Manufacturing Systems Management at the University of Huddersfield. The student was undertaking a company-based project and was based at the company on a full time basis during the project period (three months). The contact at the third case study company was the director of a multinational pharmaceutical company who was doing a part-time PhD at the Department of Transport and Logistics at the University.

The case study process at each case study company started with the company defining its problems and pressing needs for improvement in the supply chain management area which was going to be investigated. This was followed by setting up a project team led by a top management representative from the case study company along with the main contact from each case study company who was the initiator and the research supervisor as the advisor (at the third company, the top management and the initiator were one and the same person). Before the actual investigation started, familiarisation with the organisational structure and working process of each company was carried out to provide the author with an understanding of the operations at that particular company. The investigation started with discussions with relevant personnel with the aim to understand their needs and to review and assess relevant existing operational systems and methods against the identified needs. For the problem identification, investigations were carried out to establish appropriate approaches and methods needed to address the problems. Throughout the process of each case study, all observations and implications from each project were documented and are presented in the current chapter.

The first and the third case studies involved the development of different supply chain management tools, designed specifically to address the pressing needs of the companies. The first case study involved software engineering and development which was necessary because of the unavailability of a software tool to provide the necessary computational and reporting functionalities to address the identified problems. The third case study involved the development of a concept for supply chain mapping. In the development of the tool, use was made of an off-the-shelf software tool for diagramming and charting (Visio). The second case study company did not prove to be a fruitful base for the development of a supply chain management tool of any kind – it was due to the management priority on survival, rather than improvement of the current processes and practices. Therefore, case study two was used more for observational and modelling purposes rather than for suggesting improvements and actually implementing them.

The case studies were written up with a standard approach, starting with an introduction to the case study company which sets up the scene and describes the situation and background of the case. The introduction is followed by an outline of the supply chain and its immediate problems. After that, a definition of a plan to be followed is presented which aims at resolving an appropriate problem and implementing improvements in the specific part of the supply chain identified. The next part of the case study report represents a description of the actual problem solving process adopted, followed by an analysis of the results achieved. Each case study report finishes with conclusions about the achievements from the case study and general conclusions regarding the relevance of the case study to the research and how it contributes to the achievement of the research as a whole. The chapter ends with a summary and conclusions drawn from all three case studies.

It should be noted that the level of detail provided in the case studies varies from company to company due to the varying levels of detail allowed by the access granted. Respect is shown for the particular confidentiality policy of each company. Another reason for the variability of the detail of analysis and description from company to company is that the time the researcher spent at one company was different from the time available for studying another company. Besides that, the staff cooperation varied from company to company – some of the companies were more interested in carrying out the project and bringing it to a successful end, while others were too formal in facilitating the project and, in the author's opinion, failed to understand the benefits they could derive from an improved supply chain.

The three case studies each focused on a different part of the supply chain. A compromise was necessary to be made in order to make sure that the research achieves both of the following objectives: that all the major areas of the supply chain are covered by the research, and that the research is based on studies of companies of varying sizes and from different industries. The latter was necessary to ensure that the conclusions from the current chapter would be valid for as wide a range of supply chains as possible.

6.2 CASE STUDY 1: DEVELOPMENT AND IMPLEMENTATION OF A SUPPLIER RELATIONSHIP MANAGEMENT (SRM) SYSTEM AT SEDDON-ATKINSON VEHICLES (SAV)

6.2.1 INTRODUCTION TO CASE STUDY 1

The first of the three case studies that were undertaken during the research process looked into the supply chain of a company in the commercial vehicle manufacturing sector. The company had a well established international supplier base with suppliers in a number of global locations. As such, the company offered the opportunity to explore the issues of managing a large supplier base and to explore the tools and techniques that were used or needed at that particular moment in time. The analysis of the problems that purchasing management was facing led to the conclusion that an advanced tool for supplier relationship management was badly needed in order to enable the management to exercise the necessary control over the purchasing activities. Consequently, the researcher focused on addressing the need for employing such a tool and helping out in the design and development of a bespoke analytical tool for managing the relationships with the supplier base. The tool provides visibility of the supply chain facilitating the management of existing suppliers; it automatically rates individual suppliers on a five-point scale, and contributes to improved supplier selection using a novel methodology. The advantages of enhanced data visibility and minimised administration are highlighted.

The work presented here is a part of a three-year project to develop a responsive supply chain in the commercial vehicle sector. The research was funded by the Innovative Manufacturing Initiative (IMI) within the EPSRC (Engineering and Physical Sciences Research Council). Three objectives were set for the project. Firstly, to improve late configuration ability using tools appropriate to the low volume small and medium sized manufacturing enterprise (SME) by developing a generic late configuration methodology and tool. Secondly, to examine and improve the information and material flows between suppliers and the collaborating company by process mapping the whole supply chain. Thirdly, to develop a programme of supplier development based on the analysis of mapping data and supplier selection methodology to be implemented initially in selected suppliers. The researcher was directly involved in the achievement of the third objective of the project – and more specifically, in designing and developing a tool for analysing the supplier data and implementing a supplier selection methodology that was based on a company-specific supplier evaluation approach.

6.2.2 THE CASE STUDY COMPANY AND ITS SUPPLY CHAIN PROBLEMS

Seddon Atkinson Vehicles (SAV), located in Oldham, near Manchester, operates in the commercial vehicle manufacturing sector and is a wholly owned subsidiary of a major automotive player, Iveco SPA. Established in 1970, the company has gone through several ups and downs. The 200 Series truck, launched in 1975, was voted "Truck of the year". The company was then sold to a Spanish government holding company, ENASA, in 1984. the Fiat Group bought the company in 1991, and installed the company within its Heavy Truck Division of Iveco, its growing commercial vehicle company, in 1999.

At the time of the case study, there were approximately 200 staff employed in this plant, with 19% of them in the Engineering department and 60% on the production floor. Its annual sales revenue was in the range of £30 - £50 million and was certified with ISO 9001. The company designs, assembles and tests its finished products, which are mainly commercial vehicles ranging from 17 to 44 tonnes for the municipal and commercial markets. The product mix consists of municipal vehicles (32%), commercial vehicles (47%) and spare parts (21%). All the components are bought in, which explains the large supplier base supporting the company. The process type is a mixture of one-off production (50%) and small batches (50%). 20% of the products are made to stock while the rest are assembled to order (80%) with a high proportion of customer defined vehicle configurations: 75% of the trucks are customer-specific. The level of complexity in the manufacturing process is considered medium where it requires an average of 10 to 15 operations to assemble a truck. During the assembly process, the company uses in-house built applications from Iveco as well as commercially available systems, such as Cummins' Set-up Parameters Software for truck engines. The manufacturing lead-time ranges from 8 to 12 weeks and the order delivery time is from 4 to 8 weeks.

The company estimated that customised truck orders make more than 50% of its total sales value per year, while standard trucks are less than 25%. Spare component sales make up the remaining 25%. There are more than 50 variants produced for its commercial trucks and each is made of more than 50 distinct components with a high level of complexity. Over the last three years, the company has introduced more than 20 modified versions from its existing trucks and about 5 to 10 completely new trucks.

Design modularity is an adopted practice in the design process with more than ten weeks of design lead-time required. The company uses AutoCAD as its computer-aided design tool. The level of complexity in the design process is considered medium and the company claimed that it adopts a concurrent engineering approach in all its new truck introductions. Accurate product definition at the order capture stage is a key issue for the company. Whilst inter-group synergies are gradually being developed, particularly in the areas of design and the supply chain, the company operates as a relatively independent business unit.

The company is particularly strong in the domestic municipal market for refuse collection trucks partly due to the use of Cummins diesel engines. Currently, the company's annual sales represent 1.3% of the total UK truck market. This expertise is gradually being developed for the European 'municipal' market, where trucks are being manufactured in the UK but sold under the parent company brand name, Iveco, which has a greater market acceptance in Europe.

In the commercial market, competition with large mass producers is increasingly limited to 'niche' sectors where established expertise, coupled with design specification, flexibility and responsiveness, enable it to compete with less flexible mass producers.

The level of market uncertainly is considered to be medium, and the company perceives itself to be in the lower half of the sector for competitive performance among its competitors. The company has identified that speed of delivery, product variety and functionality, speedy response to customer, and focus on specific markets as the most important factors in enabling it to compete successfully in the commercial vehicles market. This is followed by other factors such as product quality and cost.

A base of regular customers has been developed which is not big enough due to the small market share in the commercial truck market (3.5%). Orders are placed via the company's network of distributors. Promised delivery dates are often not met as they can be unrealistic. The salespeople do not have information about the capacity currently available at the workshop.

SAV management sought help from the University of Huddersfield to help them identify and resolve their supply chain management problems. The University Manufacturing Systems Research Group (MSRG) undertook a study of the supply chain in order to map it and make the processes more visible and therefore, easy to analyse and improve. The initial objective was to map the supply chain of SAV, model the information and decision-making flows within it and associate them with the respective material flows in order to present the processes in a way which would be useful for the company's management i.e. would tell them something new about what is going on in the supply chain. It was found to be important to follow the decision-making flow along with the information flow (that is, to identify what decision is made when a certain kind of event occurs and triggers a certain piece of information to enter the system).

The general overview of the value adding processes within the company drew upon previous work done by researchers at the University of Huddersfield. The outcomes of the work performed by Ralph Rollins and Matthew Peck in a similar process mapping exercise were combined with the data collection and interviews carried out within the present project to build a model of the company's operations procedures.

The initial study of the supply chain of SAV helped to identify areas for future investigations and opportunities for the management to focus on specific weaknesses of the supply chain. The overall mapping started with a mapping of the decision-making flow within the supply chain. This means that the processes were followed in a direction opposite to the material flows – starting from the point where demand for the product arises and moving along to the order placement with the company, production scheduling and sourcing of the parts and materials, and finally getting to the supplier (first, second, third and so on-tier as required by the objectives of the mapping exercise). In the SAV case, the mapping went as far as the first-tier suppliers as improvements could only be made within the company and its supplier base management. This was the case because the company did not possess sufficient purchasing power to be influential over the way its suppliers run their own business. Mapping the direct suppliers and customers of SAV would provide enough information about the nature of the environment in which the company operated.

The way in which the company operates corresponds to the classical ATO (Assemble-to-order) model but the manufacturing of a part of the product range (namely, the special equipment (SE) vehicles) is more similar to the ETO (engineering-to-order) model as the customers often require equipment with special features. Figure 6.2.1 shows a theoretical ATO model factory which is a very good representation of the way SAV is structured and the route the information follows throughout the company. The model was developed by the researcher based on the works of Zhao, Ball, Lu and Song.

As a typical assemble-to-order firm, the SAV manufacturing process is typified by a large number of possible end-item configurations, all made from combinations of basic components and subassemblies. Customer delivery time requirements are often shorter than total manufacturing lead times, so production must be started in anticipation of customer orders. The large number of end-item possibilities makes forecasting exact end-item configurations extremely difficult, and stocking end-items very risky. As a result, the assemble-to-order firm tries to maintain flexibility, starting basic components and subassemblies into production, but, in general, not starting final assembly until a customer order is received.

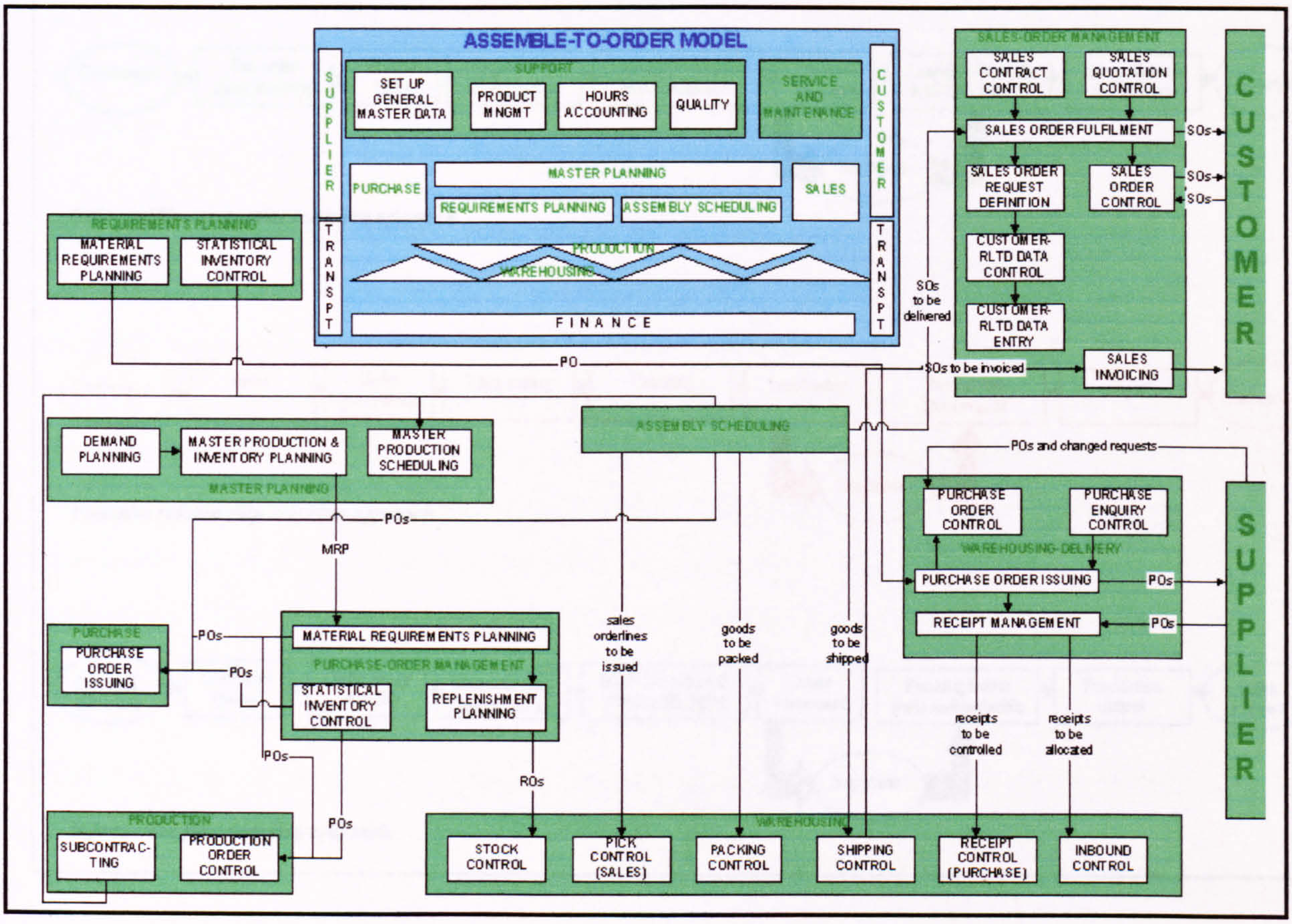


Figure 6.2.1. ***GENERIC INFORMATION FLOW AND DECISION-MAKING ROUTE IN AN ATO COMPANY (BASED ON ZHAO, BALL, LU AND SONG)***

The map can be simplified further on by distinguishing among the three distinctive flows across the model: information, decision-making and materials. Figure 6.2.2 shows the individual flows and proves that, no matter which one of the flows is followed, the map resulting from the study has a similar layout.

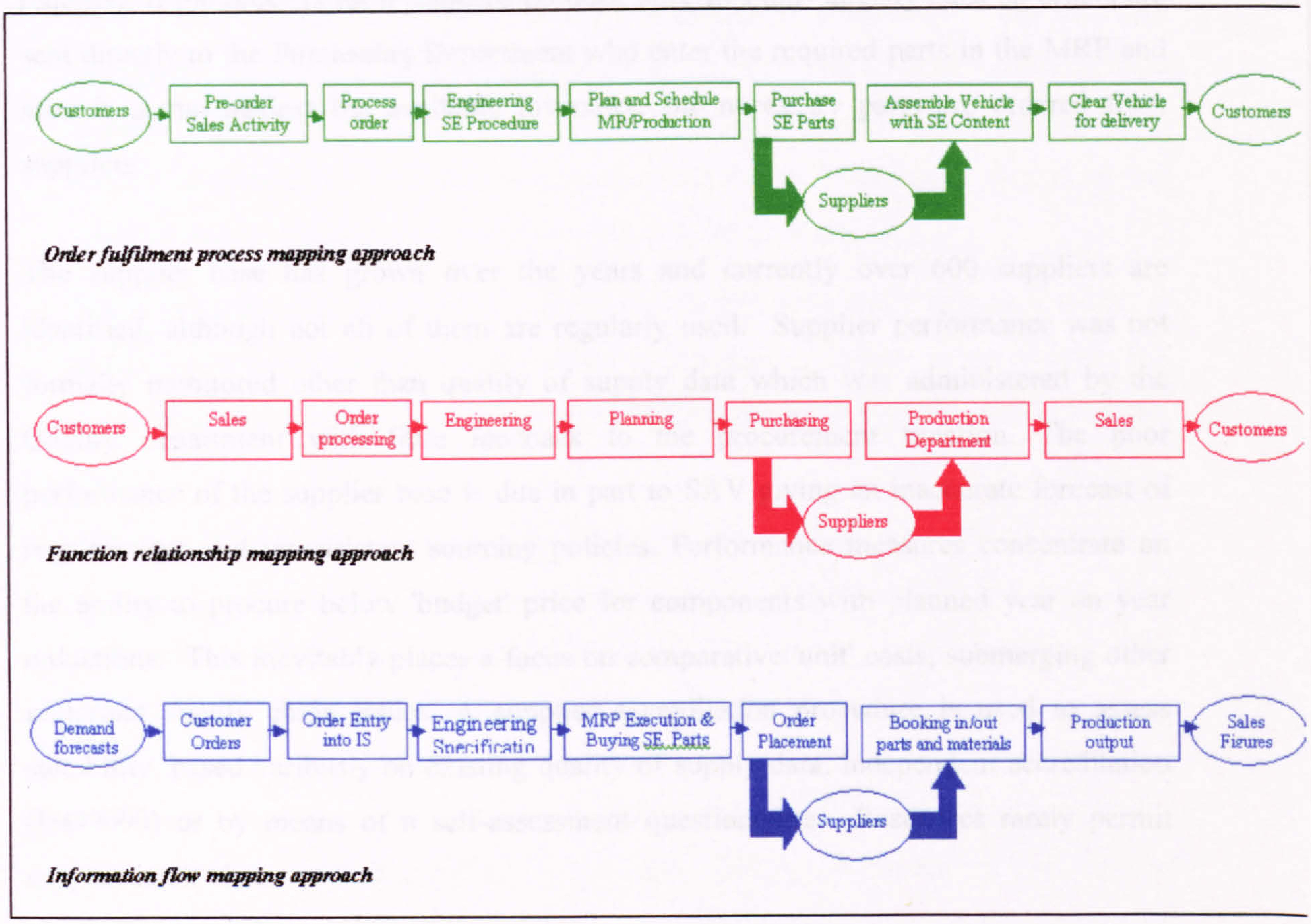


Figure 6.2.2. ***APPROACHES TO MAPPING THE PROCESSES AT SAV USED BY THE RESEARCHER***

The company uses a traditional Materials Resource Planning (MRP II) system for scheduling order requirements supplemented, where necessary, with manual orders. The MRP II cycle was compressed from a monthly to a weekly cycle as part of the project but requirements were still communicated using the postal system.

When an order is for a special equipment (SE) vehicle, the required specifications are placed with Engineering and they produce detailed engineering specifications. The Engineering specification is sent to the buyers, whose task is to source the necessary materials and parts from the existing supplier base. Sometimes they have to find a new supplier. The buyers place the order with the selected supplier to source the material required. If the order is for a standard product, specifications already exist so orders are sent directly to the Purchasing Department who enter the required parts in the MRP and after it is run against the available inventory, the necessary parts are ordered from suppliers.

The supplier base has grown over the years and currently over 600 suppliers are identified, although not all of them are regularly used. Supplier performance was not formally monitored other than quality of supply data which was administered by the Quality department with little feedback to the procurement function. The poor performance of the supplier base is due in part to SAV giving an inaccurate forecast of requirements and inconsistent sourcing policies. Performance measures concentrate on the ability to procure below 'budget' price for components with planned year on year reductions. This inevitably places a focus on comparative 'unit' costs, submerging other important supply chain issues. A supplier accreditation procedure is used to assess suitability, based variously on existing quality of supply data, independent accreditation (ISO9000) or by means of a self-assessment questionnaire. Resources rarely permit supplier audit visits.

Currently, there are two main types of sourcing procedures. One of them is operated by Walter Hexagon and is of a just-in-time type where low cost parts and materials, such as fasteners, are delivered directly to the shop floor. The rest of the suppliers deliver parts and materials against purchase orders to the store where they are stored and later transported to the shop floor.

Below are step-by-step descriptions of the two procurement procedures at the time of the start of the project. The study and analysis of the procedures helped identify the strengths and weaknesses of the established practices, as well as the availability of source data to be used for supplier analysis, assessment and classification. The overall procedure is given as a flow chart in figure 6.2.3.

Normal procedure:

1) MRP is run weekly and requirements are communicated directly to the suppliers through the MRP output for components and assemblies. The schedule created (which is actually the order) is sent to the supplier. The first two weeks of the schedules are fixed and cannot be changed, the requirements for the remaining periods in the schedule can be changed and therefore serve only as forecasts.

2) When the parts are delivered, a G.R.N. (goods received note) is issued which is attached to the order – this means that the information is already in the system. The duration of the procedure is 1 to 5 minutes. Parts are authorised for payment at this stage.

3) Parts which are stamped out (certified) by SAV are not inspected – the rest (such as new parts, safety critical parts, parts with all sorts of problems on the production floor, parts with requirements by the Ministry of Transport) go for inspection at the Inspection Department. The parts, which should undergo inspection, comprise about 10% of all parts. The duration of this procedure varies and is dependent on the parts; large parts may take up to 1 day for inspection. The whole order is not inspected – only a sample (which is specified in the G.R.N.) undergoes inspection. The required sample percentage might go up if problems happen more often on the production floor.

4) Parts that fail the inspection procedure are returned to the suppliers – they usually collect them when they come to deliver the next order. The Inspection department fills in Quality Form 24-06 (Non-conforming material report) a copy of which is sent to the Accounting Department.

5) Statistics are kept for the failure rate of the parts in two ways – by part number and by supplier. The lists contain information about the part number, order, number delivered, number retained, number rejected, and failure rate. Data is available to the Inspection department and the Quality engineer.

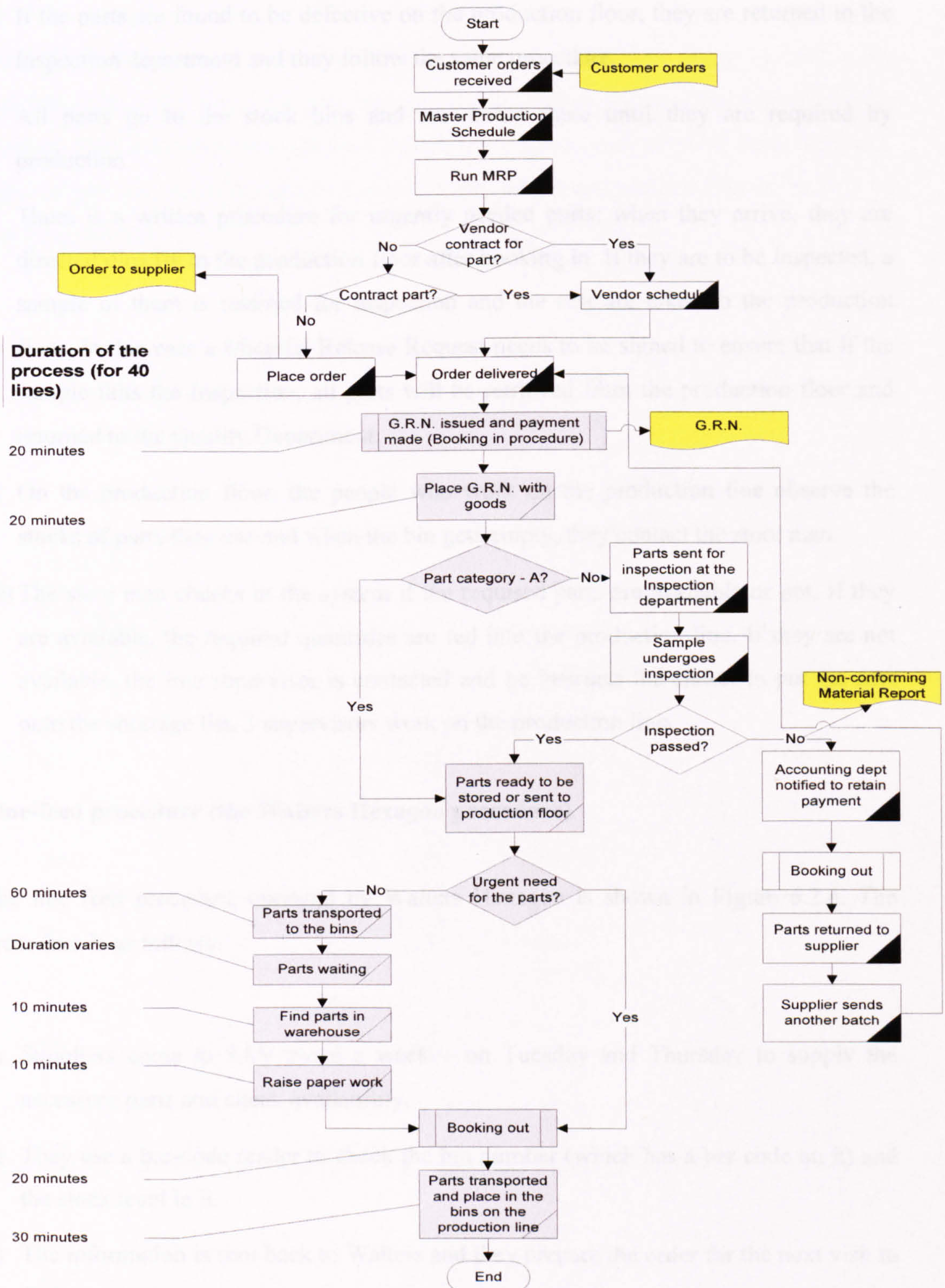


Figure 6.2.3. FLOWCHART FOR THE NORMAL PROCUREMENT PROCEDURE AT SAV

6) If the parts are found to be defective on the production floor, they are returned to the Inspection department and they follow the same procedure.

7) All parts go to the stock bins and are stored there until they are required by production.

8) There is a written procedure for urgently needed parts: when they arrive, they are directed directly to the production floor after booking in. If they are to be inspected, a sample of them is retained for inspection and the rest are taken to the production floor. In this case a Material Release Request needs to be signed to ensure that if the sample fails the Inspection, all parts will be retrieved from the production floor and returned to the Quality Department.

9) On the production floor, the people who work on the production line observe the stocks of parts they use and when the bin gets empty, they contact the store man.

10) The store man checks in the system if the required parts are available or not. If they are available, the required quantities are fed into the production line. If they are not available, the line supervisor is contacted and he instructs the chaser to put the part onto the shortage list. 3 supervisors work on the production line.

Line-feed procedure (the Walters Hexagon procedure)

The line feed procedure operated by Walters Hexagon is shown in Figure 6.2.4. The procedure is as follows:

1) Suppliers come to SAV twice a week – on Tuesday and Thursday to supply the necessary parts and check availability.

2) They use a bar-code reader to check the bin number (which has a bar code on it) and the stock level in it.

3) The information is sent back to Walters and they prepare the order for the next visit to SAV.

4) They supply the parts and check the availability other items.

The line-feed procedure is very reliable – SAV have only had problems with parts supplied in this way when the part has recently been changed from another supplier to Walters. This procedure also allows for ordering urgently needed parts from Walters – requirements are communicated to the company by telephone and the lead-time could be less than two days.

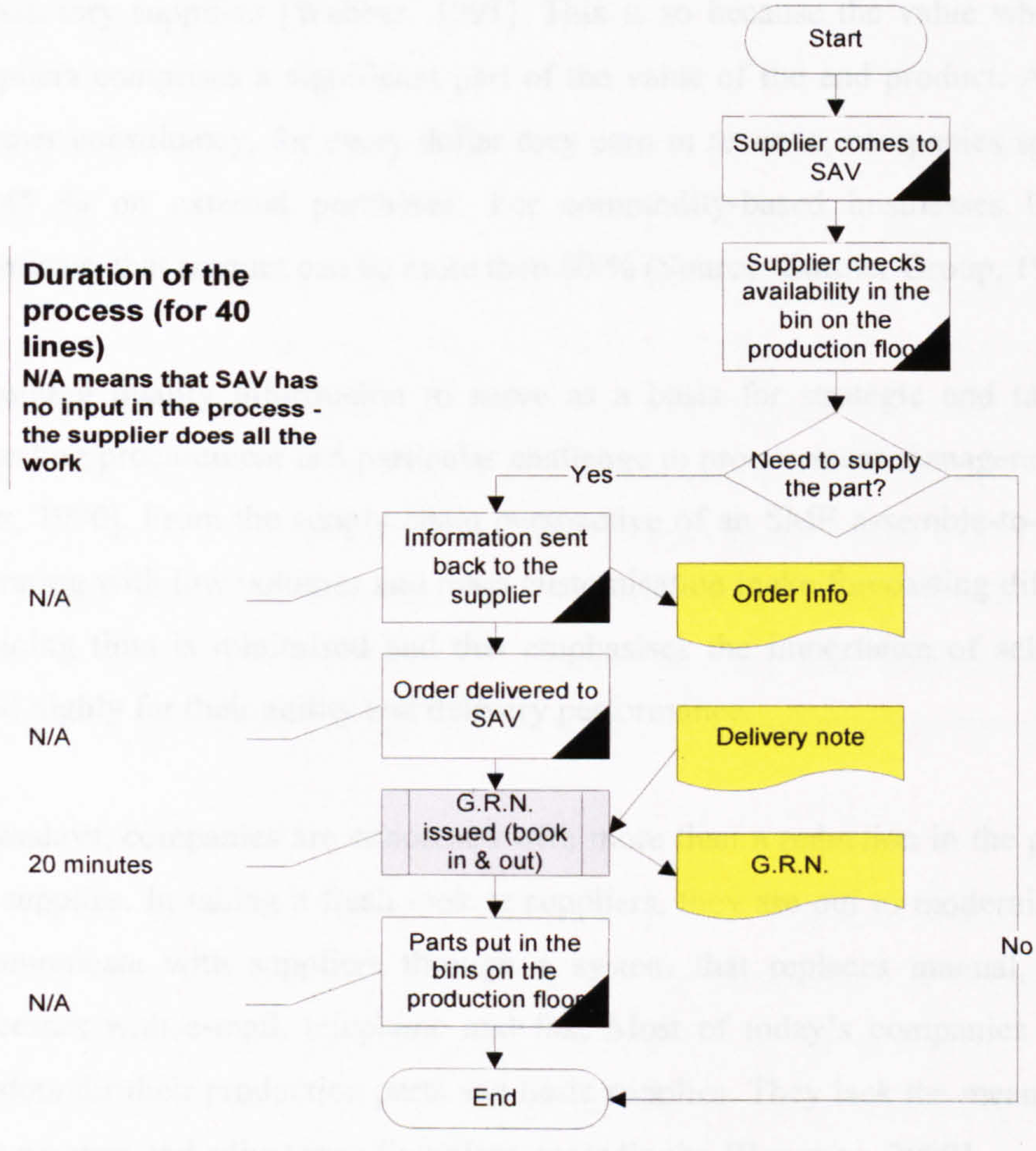


Figure 6.2.4. ***FLOWCHART FOR THE LINE-FEED PROCEDURE AT SAV***

6.2.3 VENDOR PERFORMANCE ASSESSMENT AND CLASSIFICATION SYSTEM (VENPAC)

OVERVIEW OF SRM

The value which the effective management of a company's supplier base brings to the company can not be overlooked when company management gets involved in optimising its supply chain. In today's highly competitive environment, it is almost impossible to manufacture flexibly meeting demanding quality standards at low cost without satisfactory suppliers [Webber, 1991]. This is so because the value which is added by suppliers comprises a significant part of the value of the end product. According to the Gartner consultancy, for every dollar they earn in revenue, companies spend an average of 45 % on external purchases. For commodity-based businesses like metals and chemicals, that amount can be more than 60 % (Source: Gartner Group, 1991).

Obtaining quality information to serve as a basis for strategic and tactical decisions regarding procurement is a particular challenge to procurement management [Gattorna & Kerr, 1990]. From the supply chain perspective of an SME assemble-to-order company, operating with low volumes and mass customisation make forecasting difficult. Supplier planning time is minimised and this emphasises the importance of selecting suppliers rated highly for their agility and delivery performance.

Nowadays, companies are concerned with more than a reduction in the purchasing price for supplies. In taking a fresh look at suppliers, they are out to modernise the way they communicate with suppliers through a system that replaces manual, paper-intensive processes with e-mail, telephone and fax. Most of today's companies have too many vendors for their production parts and basic supplies. They lack the means to identify the best partners and adjust spending plans accordingly. [Bowman, 2002]

All of the above helps to explain the emergence of a new subset of supply chain management: supplier relationship management (SRM). An obvious echo of customer relationship management (CRM), SRM seeks to plug a communications gap at the other end of the chain. Until now, companies have had to make do with data drawn from internally focused enterprise resource planning (ERP) systems. "Procurement people in the plant never had an application they could call their own," says Jeff Herrmann, chief executive officer and president of SupplyWorks Inc. [Herrmann, 2002]

SRM has gained popularity in the past few years, but its meaning is often unclear. It does not evoke a clearly defined set of software tools. What is definitely clear about it is that it spans multiple stages of supplier management, including design, specify, source, and process. [Barling, 2001]

A preliminary literature survey suggests that a comprehensive SRM solution framework comprises three key areas: strategic sourcing, procurement management and supplier performance monitoring [Hudson, 2002]. Effective strategic sourcing activities (spend analysis, vendor discovery and evaluation, request for quotation creation and management, scenario planning, contract creation, etc.) lay the foundation for successful long-term supplier relations. Procurement management covers the requisition to payment cycle not only for indirect goods but also for direct goods and services and begins where strategic sourcing ends. The third major area of SRM, supplier performance monitoring, serves to identify and minimize risk in the relationship and, importantly, is open to the supplier for a collaborative approach to managing the relationship based on analysis [op cit.].

In a recent report, Gartner described SRM as "the practices needed to establish the business rules, and the understanding needed for interacting with suppliers of products and services of varied criticality to the profitability of the enterprise." [Gartner, 2001] That tells enough about the importance that Gartner attributes to SRM but again, it does not give a precise idea of the essence of those practices and does not put SRM in precise terms. Further on, Gartner tries to define the scope of SRM by introducing the diagram in Figure 6.2.5. While the scope of SRM is well defined, clarity about the way it is performed is still missing.

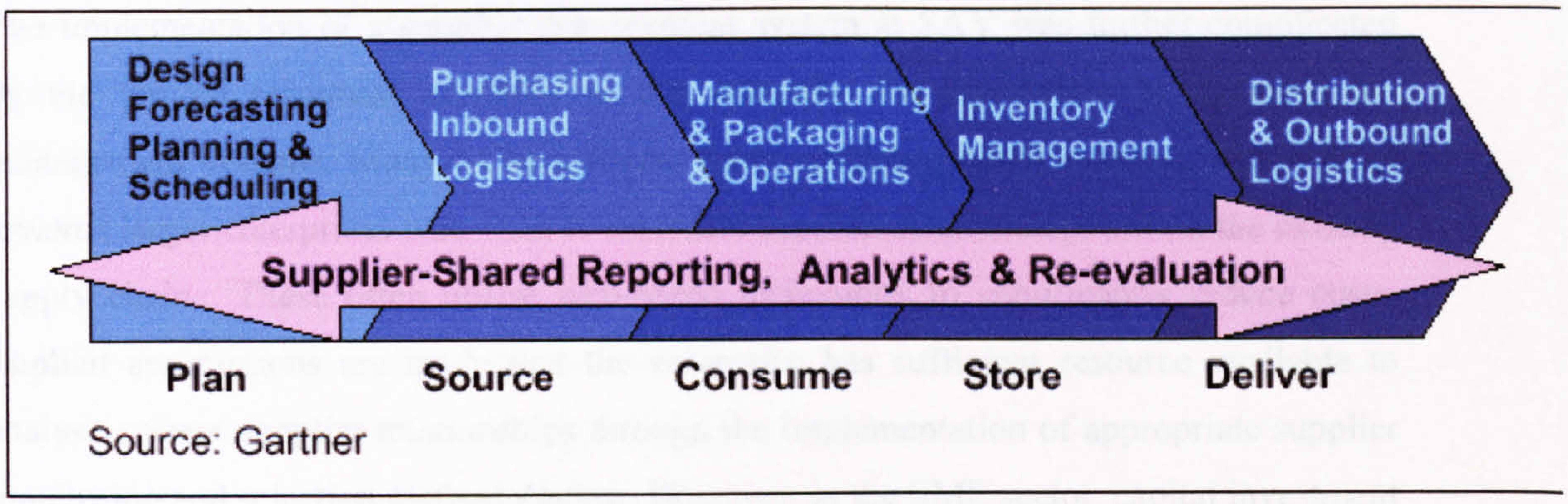


Figure 6.2.5. SRM SPANS FUNCTIONAL AND ENTERPRISE BOUNDARIES [GARTNER, 2001]

Herrmann makes an attempt to throw further light on the subject, saying that SRM solutions include the tactical transaction mechanisms for communicating orders to suppliers and automating procurement. SRM also provides the strategic management tools to develop more collaborative relationships with suppliers and to manage those relationships to drive cost reductions, faster cycle times and greater flexibility in their supply chains.

In conclusion from the above discussion it can be said that SRM is a concept which is still undergoing development and is too broad and unspecific to be confined to a particular function, application or to be managed with the help of a simple software solution. The author's interpretation of SRM for the purposes of the thesis is as follows:

> "SRM is a comprehensive approach, supported by the appropriate software, to managing an enterprise's interactions with the organizations that supply the goods and services it uses. The goal of SRM software is to streamline and make more effective the processes between an enterprise and its suppliers."

This definition is at the heart of the current case study and forms the basis of the development of the SRM system at SAV.

The implementation of a supplier management system at SAV was further complicated by the limited resources available at the company for investment in updating the management systems. Many SCM software tools, including SRM systems, are targeted towards larger enterprises who wish to automate supplier relationships within the existing supply chain. These often utilise web-based technology to significantly reduce costs. Implicit assumptions are made that the enterprise has sufficient resource available to analyse current supplier relationships through the implementation of appropriate supplier monitoring and selection methodologies. However, in the SME sector, capital investment constraints limit investments for new technology, functional structures are less prevalent and, generally, human resources are preoccupied with 'doing' rather than 'evaluating'.

The above is the reason why many SME category manufacturers still procure requirements based on clerical procedures where data for analysis is often difficult to obtain [Hilmola & Ylinen, 1999]. In the manufacturing sector, greater visibility of the diversity of supplier relationships will assist the implementation of strategic objectives providing data to improve supplier selection.

An understanding of the nature of the supply relationship is also necessary, particularly whether alternative supply options exist. Consideration also needs to be given to other issues such as geographical and currency factors since these can have a bearing on organisational costs and flexibility.

To begin to evaluate the performance of the supply chain, it is necessary to rate the performance of individual suppliers. In addition to pricing issues, it is necessary to analyse suppliers' comparative strengths and weaknesses in terms of quality of supplies (reject rates), delivery performance (delivering required quantities when requested) and the responsiveness of the supplier across a range of issues from design capability, management, pro-activity to conflict resolution.

It is often surprising to see how little attention is given to the assessment of potential sources of supply in any structured way. The objective must be to identify which potential suppliers are best equipped to help the company achieve its purchasing strategy [Saunders, 1997]. Assessment begins with a process of evaluation and approval against predetermined criteria and purchasing-supplier relationships tend to fall into three categories:

- Competitive - Contracts placed for tender
- Negotiation - Traditional negotiation interaction
- Alliance - Referred to a supply partnership

DESIGN AND SYSTEM ARCHITECTURE

Literature emphasises the importance of aligning supply chain strategy with strategic objectives [Spear, 1997] and with the provision of performance measures based upon accepted quality models and standards. During the initial development stage, the author held several discussions with the collaborating company interviewing management, practitioners and a selection of suppliers to review the company approach. It became clear that the available resource to monitor the supply chain was limited and a 'fire fighting' approach tended to be the usual way to resolve problems. Supplier performance data was too difficult or too time consuming to obtain so only the performance of extremely successful or extremely bad suppliers tended to come to prominence. Supplier selection was based on historical factors or was effectively passed to the engineering function. Suppliers received minimal feedback on their performance, confirming the fire fighting culture and complained about a lack of forecast requirements.

Three particular conclusions emerged:

- No formal system was used to rate supplier performance, comparisons between suppliers tended to be based on anecdotal evidence.
- In general, the strategic requirement to emphasise supply chain flexibility was not given sufficient consideration in supplier selection.
- The size of the supplier base dissipated the procurement resource leading to limited contacts with a wide range of individual suppliers.

In order to address the above issues, the research team undertook the task to develop a bespoke supplier relationship management system which would address the particular problems that the company was facing at that moment in time. The system would be used to retrieve data from the mainframe database system and process it to convert it into information to be used by decision-makers. The main functions of the system would be to assess the numerous suppliers' performance in terms of quality of supplies, delivery times and costs and to classify them on that basis into easily manageable categories. Hence the name of the system – vendor performance assessment and classification system, or, in short, VenPAC. The term "vendor" was used instead of "supplier" simply because the parent company in Italy had adopted that term and used it in their supplier relationship management practice.

A PC-based platform using the MS Access development tool was chosen as the operating platform for VenPAC. It forms part of the MS Office package and is available within the collaborating company. The only training required is on the system functionality. Initially, the targeted end-users were mainly those involved in the procurement and materials management function. However, the viewing facility later became available to other functions within the organisation including engineering, production management and finance.

As agreed from initial discussions, where and when necessary, information available from the company's mainframe AS/400 is imported or 'read' by VenPAC via ANSI formatted text files. This avoids duplication of data entry and eliminates possible errors from human intervention. VenPAC is also linked to another database tool: Production and Shortage Control System (ProTSC), which was developed in an earlier phase of the IMI project. In order to respond to priorities set by the collaborating company, some of the 'Schedule Order' functionality was developed in the above system to provide on screen visibility of current order schedules, arrears and over-delivery data, parts inventory and parts status data.

In order to maximise the generic application for the SME sector; VenPAC can be used by manually entering data circumventing the need for data transfer. To ensure data integrity, VenPAC is designed to provide access to data on 'read and write' or 'read only' basis depending on individual user 'login' authorisation. With the exception of vendor quality data and mapping data, which is entered by SAV quality and purchasing staff respectively, all data within VenPAC is derived from core SAV systems and 'read' via text files.

VENPAC SYSTEM OVERVIEW

The VenPAC (Figure 6.2.6. VenPAC Main Screen) system provides a central database for Vendor records relating to purchase costs, quality of supplies, delivery performance, quality audit records and supply chain mapping and search data. VenPAC requires minimum administration and adopts an easy to use windows format. It provides a suite of automatically produced on-screen information, reporting and graphics functionality based on the 'current' month and last 12 months' Vendor data, such as deliveries, costs, rejects, arrears, over-deliveries.

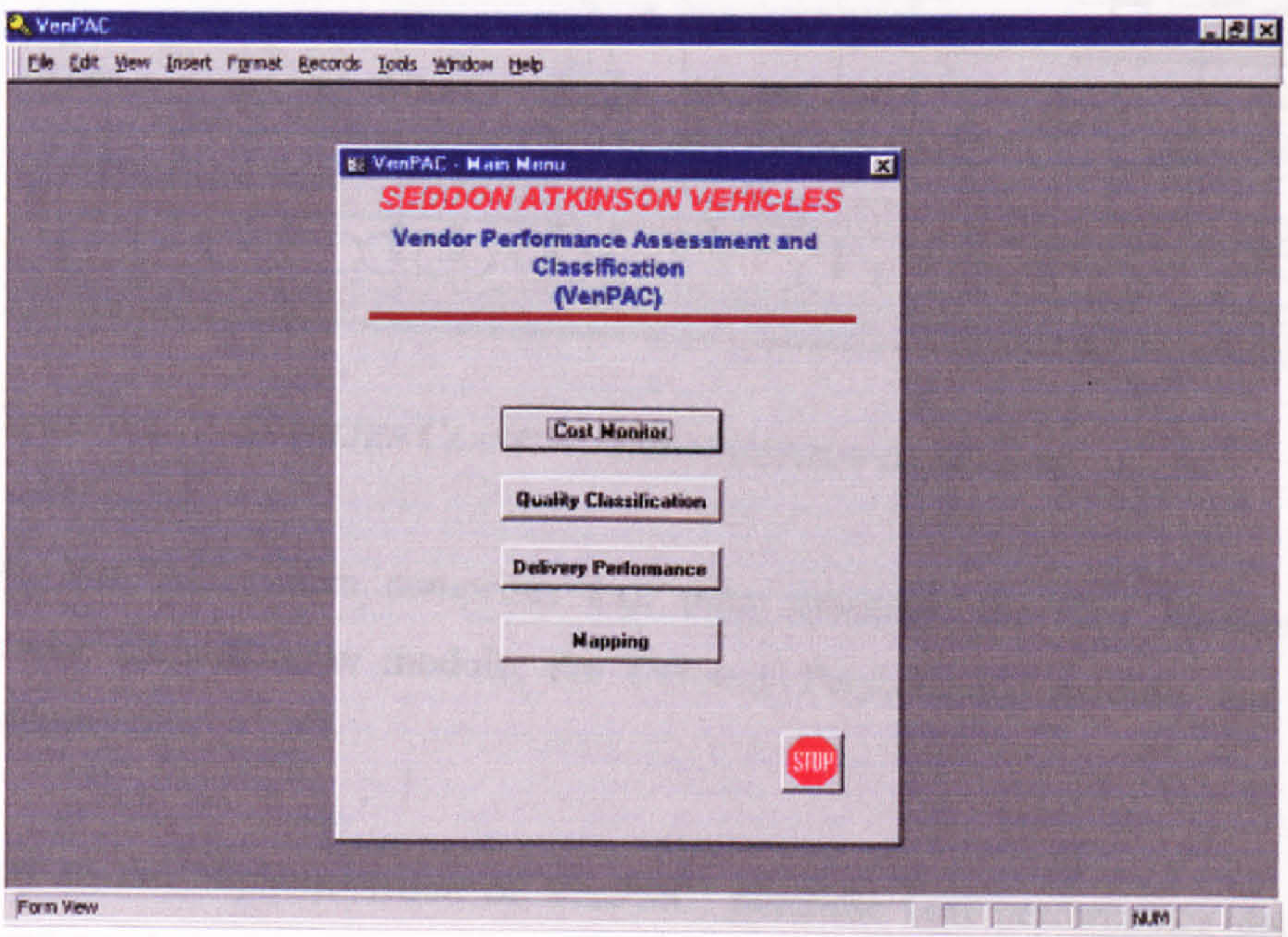


Figure 6.2.6. ***VENPAC MAIN SCREEN***

VenPAC automatically calculates Vendor classifications using a novel methodology (shown in the diagram in Figure 6.2.7: Supplier Classification Method Overview). The vendor classification has several purposes. Firstly, to easily distinguish between good and poor suppliers, secondly to influence future procurement decisions for new or re-sourced parts, thirdly to direct quality effort to where it is most needed, and finally, to allow comparisons with other supply chains using a similar methodology (such as the parent company's supply chain).

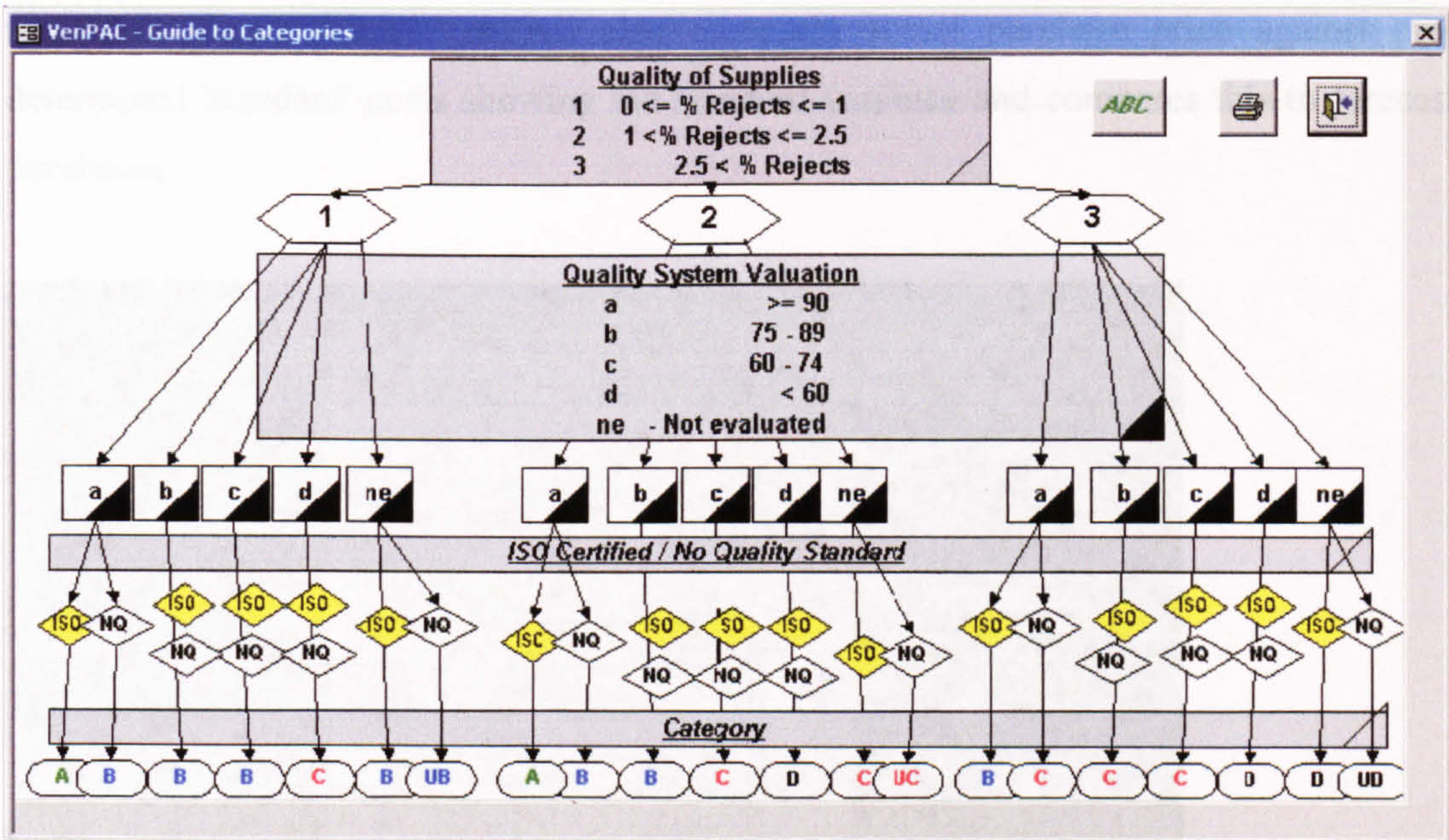


Figure 6.2.7. SUPPLIER CLASSIFICATION METHOD OVERVIEW

The VenPAC system comprises four main modules: the *Cost Monitor* module, the *Vendor Classification* module, the *Delivery Performance* module, and the *Mapping* module.

Prior to the implementation of VenPAC, purchase cost performance data (comparing actual purchase costs to predetermined standards) was issued monthly in printout format. Only one copy was produced and the purchasing manager retained this. A monthly purchasing report was prepared based on the 100 suppliers with the largest spend as part of the group reporting requirement. This was prepared in an Excel spreadsheet and took approximately three days to prepare. Due to limited resources, the perceived top 100 suppliers were chosen at the beginning of the year and no consideration was given to variations caused by changing spending patterns. Inevitably, errors were identified in the manually prepared report.

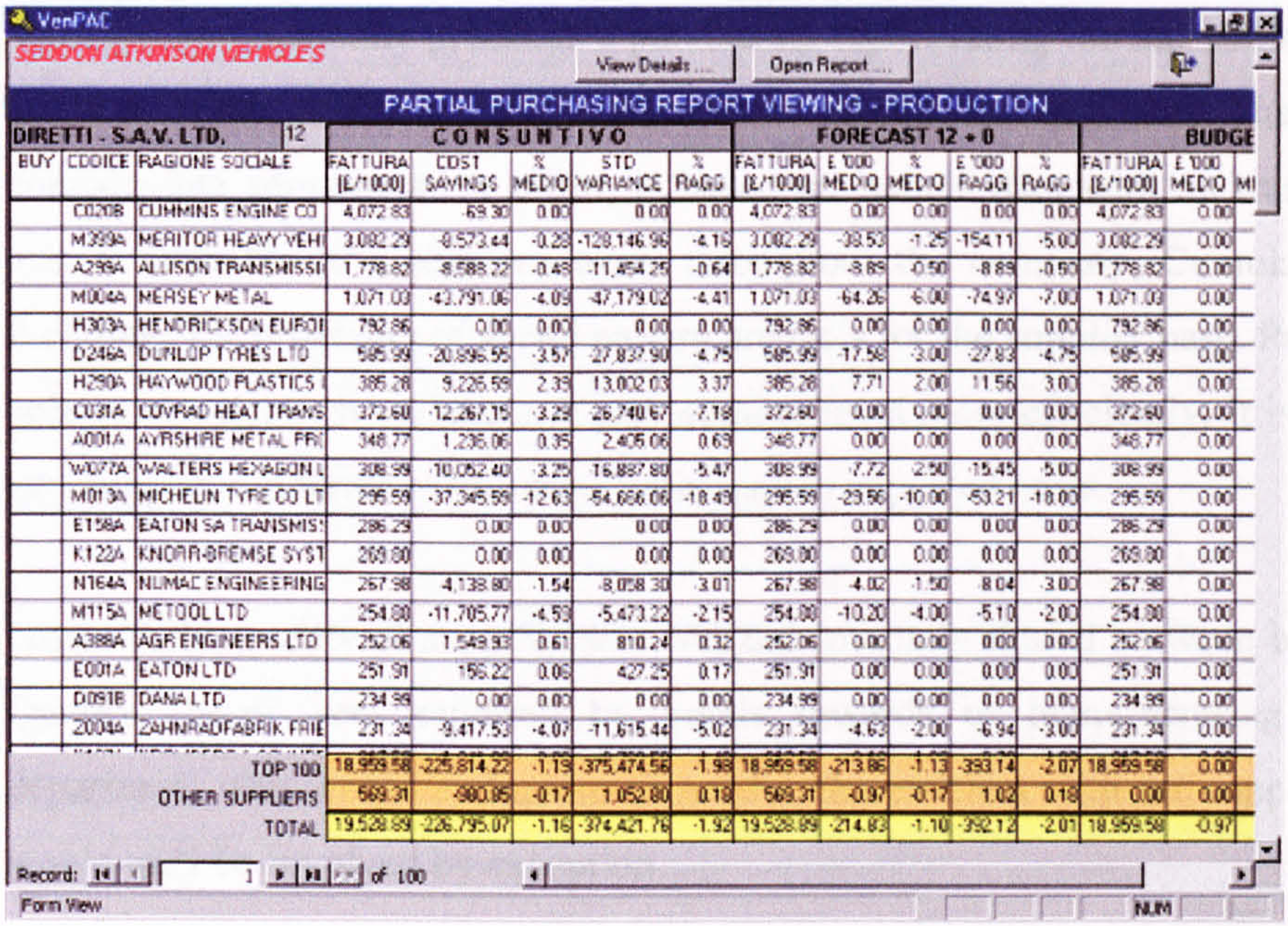
The Purpose of the Cost Monitor module is to provide easy access to purchase/delivery information by Vendor. Accessed through the VenPAC Cost Monitor Opening Screen, shown in Figure 6.2.8 VenPAC also compares actual purchase price against pre-determined 'standard' costs showing the standard variance and compares this to forecast purchases.

Figure 6.2.8. VENPAC COST MONITOR OPENING SCREEN

VenPAC organises the data to rate vendors in terms of their cumulative spend to date and also calculates the percentage spend by vendor compared to the total spend to date. A partially automated monthly report is also generated to facilitate SAV purchasing performance reporting for the IVECO Group.

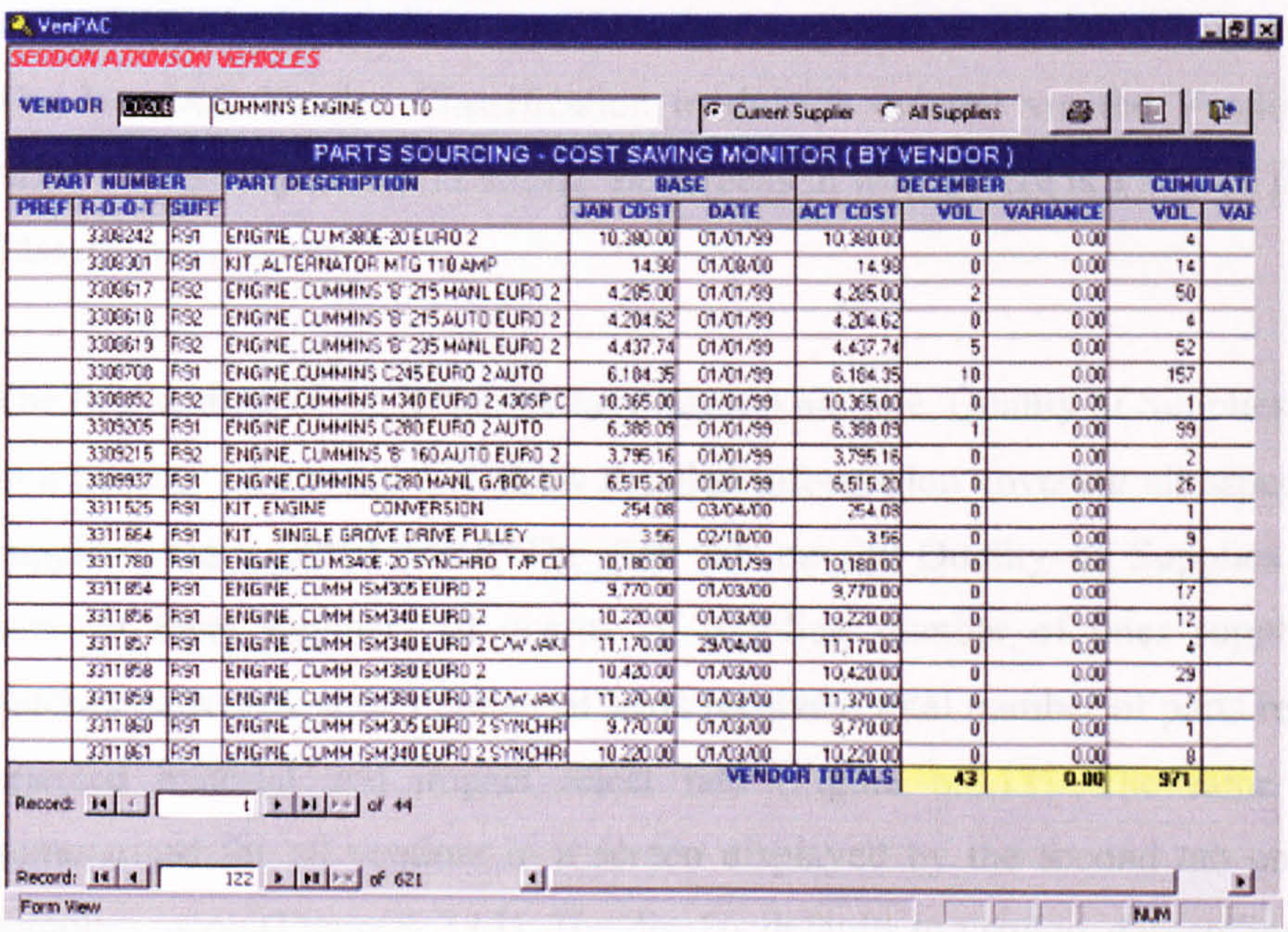
Upon entering the Cost Monitor Screen (Figure 6.2.8) the user is prompted to select a particular month. This enables the user to view delivery and purchase cost details for the selected month together with year to date (YTD) information. Usually, the most recent month will be selected. A 'download' function button allows the latest cost and delivery information to be automatically imported into the VenPAC cost monitor - this only takes a few seconds and must be performed each month to ensure that VenPAC is reading the latest data. The system automatically checks for new files in the upload area of the company's network and if it detects the presence of an updated file, it comes up with a message that the download should be performed in order to ensure that VenPAC is using the latest data.

VenPAC shows the actual spend, forecast and budget for each supplier, as shown in Figure 6.2.9. Data is presented in summarised form automatically calculating cost variances and comparisons to budget. A facility is provided to 'drill down' from the summary to look at individual suppliers on a part number basis (Figure 6.2.10. Cost Saving Monitor By Vendor). Also forecasts can be amended through a subroutine.



DIRETTI - S.A.V. LTD.	12		CONSUNTIVO					FORECAST 12 + 0					BUDGE	
BUY	CODICE	RAGIONE SOCIALE	FATTURA (£/1000)	COST SAVINGS	% MEDIO	STD VARIANCE	% RAGG	FATTURA (£/1000)	£ '000 MEDIO	% MEDIO	£ '000 RAGG	% RAGG	FATTURA (£/1000)	£ '000 MEDIO
	C0208	CUMMINS ENGINE CO	4,072.83	-69.30	0.00	0.00	0.00	4,072.83	0.00	0.00	0.00	0.00	4,072.83	0.00
	M399A	MERITOR HEAVY VEHI	3,082.29	-8,573.44	-0.28	-128,146.96	-4.16	3,082.29	-38.53	-1.25	-154.11	-5.00	3,082.29	0.00
	A299A	ALLISON TRANSMISSI	1,778.82	-8,588.22	-0.48	-11,454.25	-0.64	1,778.82	-8.89	-0.50	-8.89	-0.50	1,778.82	0.00
	M004A	MERSEY METAL	1,071.03	-43,791.06	-4.09	-47,179.02	-4.41	1,071.03	-64.26	-6.00	-74.97	-7.00	1,071.03	0.00
	H303A	HENDRICKSON EURO	792.86	0.00	0.00	0.00	0.00	792.86	0.00	0.00	0.00	0.00	792.86	0.00
	D246A	DUNLOP TYRES LTD	585.99	-20,896.55	-3.57	-27,837.90	-4.75	585.99	-17.58	-3.00	-27.83	-4.75	585.99	0.00
	H290A	HAYWOOD PLASTICS	385.28	9,226.59	2.39	13,002.03	3.37	385.28	7.71	2.00	11.56	3.00	385.28	0.00
	C031A	COVRAD HEAT TRANS	372.60	-12,267.15	-3.29	-26,740.67	-7.18	372.60	0.00	0.00	0.00	0.00	372.60	0.00
	A001A	AYRSHIRE METAL PR	348.77	1,236.06	0.35	2,405.06	0.69	348.77	0.00	0.00	0.00	0.00	348.77	0.00
	W077A	WALTERS HEXAGON L	308.99	-10,052.40	-3.25	-16,887.80	-5.47	308.99	-7.72	-2.50	-15.45	-5.00	308.99	0.00
	M013A	MICHELIN TYRE CO LT	295.59	-37,345.59	-12.63	-54,666.06	-18.49	295.59	-29.56	-10.00	-53.21	-18.00	295.59	0.00
	E158A	EATON SA TRANSMIS	286.29	0.00	0.00	0.00	0.00	286.29	0.00	0.00	0.00	0.00	286.29	0.00
	K122A	KNORR-BREMSE SYST	269.80	0.00	0.00	0.00	0.00	269.00	0.00	0.00	0.00	0.00	269.00	0.00
	N164A	NUMAC ENGINEERING	267.98	4,138.80	1.54	8,058.30	3.01	267.98	4.02	1.50	8.04	3.00	267.98	0.00
	M115A	METOOL LTD	254.80	-11,705.77	-4.59	-5,473.22	-2.15	254.00	-10.20	-4.00	-5.10	-2.00	254.00	0.00
	A388A	AGR ENGINEERS LTD	252.06	1,549.93	0.61	810.24	0.32	252.06	0.00	0.00	0.00	0.00	252.06	0.00
	E001A	EATON LTD	251.91	156.22	0.06	427.25	0.17	251.91	0.00	0.00	0.00	0.00	251.91	0.00
	D091B	DANA LTD	234.99	0.00	0.00	0.00	0.00	234.99	0.00	0.00	0.00	0.00	234.99	0.00
	Z004A	ZAHNRADFABRIK FRIE	231.34	-9,417.53	-4.07	-11,615.44	-5.02	231.34	-4.63	-2.00	-6.94	-3.00	231.34	0.00
		TOP 100	18,959.58	-225,814.22	-1.19	-375,474.56	-1.98	18,959.58	-213.86	-1.13	-393.14	-2.07	18,959.58	0.00
		OTHER SUPPLIERS	569.31	-980.85	-0.17	1,052.80	0.18	569.31	-0.97	-0.17	1.02	0.18	0.00	0.00
		TOTAL	19,528.89	-226,795.07	-1.16	-374,421.76	-1.92	19,528.89	-214.83	-1.10	-392.12	-2.01	18,959.58	-0.97

Figure 6.2.9. VENPAC COST MONITOR SCREEN



PART NUMBER			PART DESCRIPTION	BASE		DECEMBER			CUMULATI	
PREF	R-O-O-T	SUFF		JAN COST	DATE	ACT COST	VOL.	VARIANCE	VOL.	VAR
	3308242	R91	ENGINE, CU M380E-20 EURO 2	10,380.00	01/01/99	10,380.00	0	0.00	4	
	3308301	R91	KIT, ALTERNATOR MTG 110 AMP	14.98	01/08/00	14.98	0	0.00	14	
	3308617	R92	ENGINE, CUMMINS 'B' 215 MANL EURO 2	4,205.00	01/01/99	4,205.00	2	0.00	50	
	3308618	R92	ENGINE, CUMMINS 'B' 215 AUTO EURO 2	4,204.62	01/01/99	4,204.62	0	0.00	4	
	3308619	R92	ENGINE, CUMMINS 'B' 235 MANL EURO 2	4,437.74	01/01/99	4,437.74	5	0.00	52	
	3308708	R91	ENGINE,CUMMINS C245 EURO 2 AUTO	6,184.35	01/01/99	6,184.35	10	0.00	157	
	3308852	R92	ENGINE,CUMMINS M340 EURO 2 430SP C	10,365.00	01/01/99	10,365.00	0	0.00	1	
	3309205	R91	ENGINE,CUMMINS C280 EURO 2 AUTO	6,388.09	01/01/99	6,388.09	1	0.00	99	
	3309215	R92	ENGINE, CUMMINS 'B' 160 AUTO EURO 2	3,795.16	01/01/99	3,795.16	0	0.00	2	
	3309937	R91	ENGINE,CUMMINS C280 MANL G/BOX EU	6,515.20	01/01/99	6,515.20	0	0.00	26	
	3311525	R91	KIT, ENGINE CONVERSION	254.08	03/04/00	254.08	0	0.00	1	
	3311664	R91	KIT, SINGLE GROVE DRIVE PULLEY	3.56	02/10/00	3.56	0	0.00	9	
	3311780	R91	ENGINE, CU M340E-20 SYNCHRO T/P CL	10,180.00	01/01/99	10,180.00	0	0.00	1	
	3311854	R91	ENGINE, CUMM ISM305 EURO 2	9,770.00	01/03/00	9,770.00	0	0.00	17	
	3311856	R91	ENGINE, CUMM ISM340 EURO 2	10,220.00	01/03/00	10,220.00	0	0.00	12	
	3311857	R91	ENGINE, CUMM ISM340 EURO 2 C/W JAK	11,170.00	29/04/00	11,170.00	0	0.00	4	
	3311858	R91	ENGINE, CUMM ISM380 EURO 2	10,420.00	01/03/00	10,420.00	0	0.00	29	
	3311859	R91	ENGINE, CUMM ISM380 EURO 2 C/W JAK	11,370.00	01/03/00	11,370.00	0	0.00	7	
	3311860	R91	ENGINE, CUMM ISM305 EURO 2 SYNCHR	9,770.00	01/03/00	9,770.00	0	0.00	1	
	3311861	R91	ENGINE, CUMM ISM340 EURO 2 SYNCHR	10,220.00	01/03/00	10,220.00	0	0.00	8	
					VENDOR TOTALS		43	0.00	971	

Figure 6.2.10. VENPAC COST SAVING MONITOR BY VENDOR

VenPAC automatically produces a purchasing report rating the top 100 suppliers by year to date spends and calculates a cumulative spend for suppliers. The report saves a considerable administrative effort, is based on 'actual' data with no transposition errors and is available to authorised users throughout the company. Cumulative spend data facilitates the provision of spend pattern analysis for the supplier base. Purchasing is now able to monitor cost variances at part number level more efficiently. It is also possible to rate suppliers in terms of purchase variations to expected costs.

Historically, quality of supplies data was not routinely shared between interested parties. Quality issues were reported by goods inwards or manufacturing to the quality department who would endeavour to resolve the problem with the supplier. Purchasing would only be involved by exception.

VenPAC provides a fast and reliable automated way to assess and classify the current supplier base of the company. The Vendor Classification module contains a number of sub-modules, which will be discussed individually.

The VenPAC Vendor Classification module is entered via the Vendor Classification Main Screen. Figure 6.2.11 shows the screens to which there is a link on the main Vendor Classification screen.

The first section of the Vendor Classification module, Quality of Supplies, displays a link to a number of screens that show detailed information covering all aspects of quality of supplies and rejected parts. The first tab on the Quality of Supplies menu displays supplier level summary of quality of supplies, number of lines supplied, number of batches delivered, total number of parts received, total number of parts rejected, value of rejected material and impact reject rate (Figure 6.2.12). The same information is summarised for all vendors in a screen displayed by the second tab on the Quality of Supplies menu (Figure 6.2.13). The display defaults to vendors descending by impact rate (time weighted reject percentage) but also includes the standard reject percentage figure together with a calculation of the cost of reject parts. The display can be re-sorted prior to viewing or printing by invoking the sort functionality.

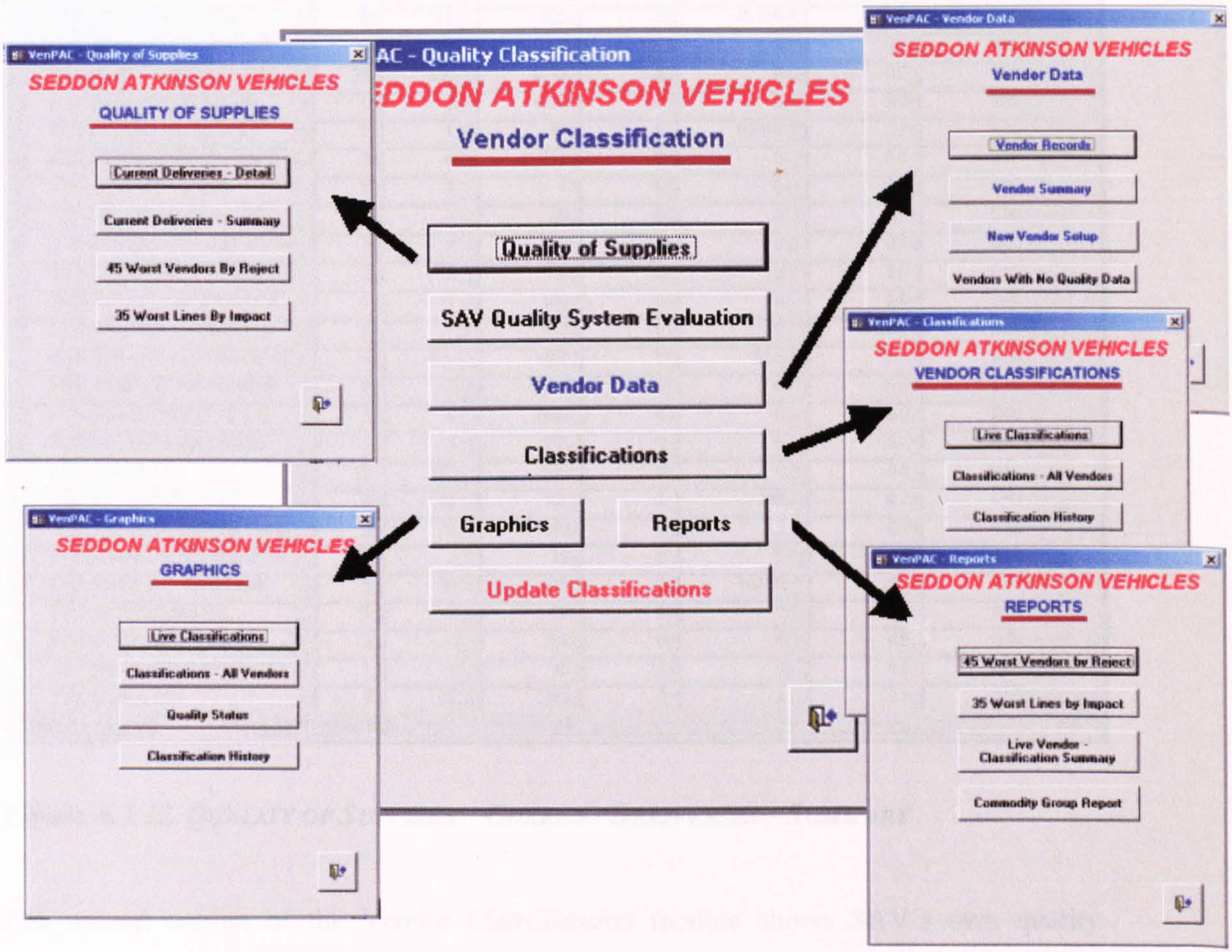


Figure 6.2.11. VENPAC VENDOR CLASSIFICATION MAIN SCREEN AND LINKS

Two reports are available in the Quality of Supplies menu. The 45 worst vendors by reject rate helps management identify the vendors who consistently perform poorly on this criterion. The second report lists the 35 part lines with highest impact rate, this helps management identify the purchasing of which part numbers needs attention to ensure that manufacturing does not get held up due to their lack at the point of use.

VenPAC - Quality of Supplies

SEDDON ATKINSON VEHICLES

QUALITY OF SUPPLIES

CURRENT DELIVERIES - SUMMARY

Code	Vendor Name	#Lines	#Batches	TotalRcvd	TotalRejtd	CostOfRejcts	% REJECTS	IMPACT RATE
F233	FIAMM AUTOMOTIVE LTD	2	30	666	0	0	0.0	0.00
F195	K & A FURNESS LTD	21	85	1246	0	0	0.0	0.00
F200	FONDERGHISA SPA	5	11	620	2	46.318	0.3	0.00
F203	FELSAN PERFECTO Y PE	2	3	1037	0	0	0.0	0.00
A251	ARTEL RUBBER CO LTD	35	899	6193	0	0	0.0	0.00
F214	FANTI FULVIO DI FANT	1	2	4299	0	0	0.0	0.00
F215	FILTRAUTO ITALIA S.R	1	1	30	1	18.876	3.3	0.00
G233	GENERAL MECCANICA C	2	4	110	0	0	0.0	0.00
F227	FELSTED EUROPE	1	1	1	0	0	0.0	0.00
F235	GEORG FISCHER GMBH	1	1	20	0	0	0.0	0.00
G008	GOODYEAR GREAT BRITA	2	2	6	0	0	0.0	0.00
G008	GOODYEAR TYRE RUBBEI	2	2	6	0	0	0.0	0.00
G093	GENTECH INTERNATIONA	1	1	100	0	0	0.0	0.00
G143	GREEN BROTHERS LTD	2	7	313	0	0	0.0	0.00
G208	GROENEVELD TRANSP EF	15	166	1407	1	59.5	0.1	0.00
K036	KEIGHLEY IND FASTENE	2	7	2288	0	0	0.0	0.00
W286	WHITE PRODUCTS B.V.	2	6	2400	0	0	0.0	0.00
E157	HELMUT ELGES GMBH	1	7	160	0	0	0.0	0.00
E001	EATON LTD	12	163	556	0	0	0.0	0.00
E068	EBERSPACHER (UK) LTD	8	42	151	1	398	0.7	0.00
E105	EUROTEC INTERNATIONA	3	23	1080	0	0	0.0	0.00
E123	ECONOMATICS (INDUSTR	2	2	16	0	0	0.0	0.00
E125	EXIDE BATTERIES LIMI	5	34	775	2	102.36	0.3	0.00
E147	EVERGOMMA SRL	1	3	60	0	0	0.0	0.00
E152	ELTH S.A.	3	3	796	0	0	0.0	0.00
A302	AUTOMOTIVE PRODUCTS	1	6	60	0	0	0.0	0.00
E156	ELMEG SRL	3	16	340	0	0	0.0	0.00

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Figure 6.2.12. Quality of Supplies – Current Deliveries – Summary

The second section of the Vendor Classification module shows SAV's own quality assessment of its suppliers. Suppliers are awarded a quality system evaluation factor of 0 to 100 on the basis of questionnaires about their quality procedures which they fill in themselves. the section also displays information about the current status of the supplier – suppliers can belong to one of the following groups:

APPD – suppliers who are approved and are being currently used;

PEND – suppliers whose assessment is pending. Usually this means that a questionnaire has already been sent out but no response has been received yet;

NOGO – suppliers who are being used but are going to be cancelled as soon as another supplier has been found for the parts supplied by them;

CANC – suppliers who have been cancelled and are no longer used.

Another section in the Vendor Classification module displays summarised supplier information – this section provides links to individual supplier records and to a list of suppliers with the most essential information for each one of them. It also provides facilities to set up a new supplier and to identify suppliers who have been referred to as suppliers of parts but have not been set up with their contact information, quality system evaluation, etc.

VenPAC uses a novel methodology to evaluate and classify supplier performance reclassifying automatically on a monthly basis. This generates supplier classifications based on a five-point scale rating suppliers A, B, C, D or unclassified. 'A' rated being a supplier with an excellent quality of supply record, excellent audit result and evidence of independent accreditation (ISO9001 or similar). The classification of U represents an unclassified category that is used when at least one element of the essential classification data is missing. Figure 6.2.14. Guide to Classifications shows a detailed description of each category.

The methodology first considers the quality of supplies data based on 'actual' deliveries, assigning values depending on the rejection rate for all parts supplied. A second level considers the collaborating companies audit data taking into account (depending on the purchasing relationship) such aspects as supplier process controls, engineering capability, agility, management etc. Finally, independent accreditation data is used to provide an independent view of supplier capability. The methodology has been designed so that it is possible to modify the vendor classification method to encompass cost variances and delivery performance into the above criteria. At the request of the collaborating company, these factors have been omitted from the classification method in order to facilitate comparisons with classification data generated by other manufacturing plants within the parent group. The diagram in Figure 6.2.7 shown earlier depicts the way that VenPAC calculates the classification category.

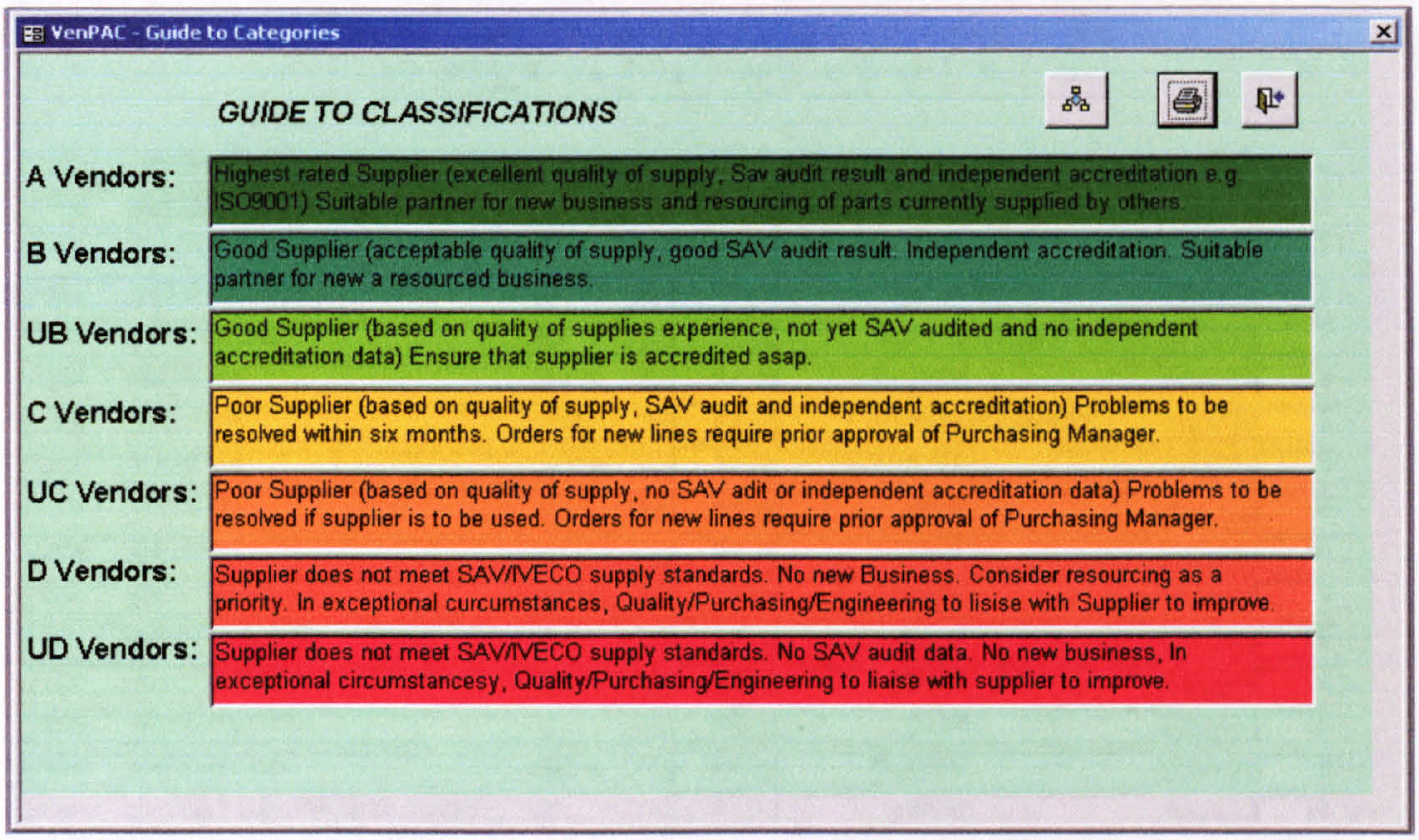
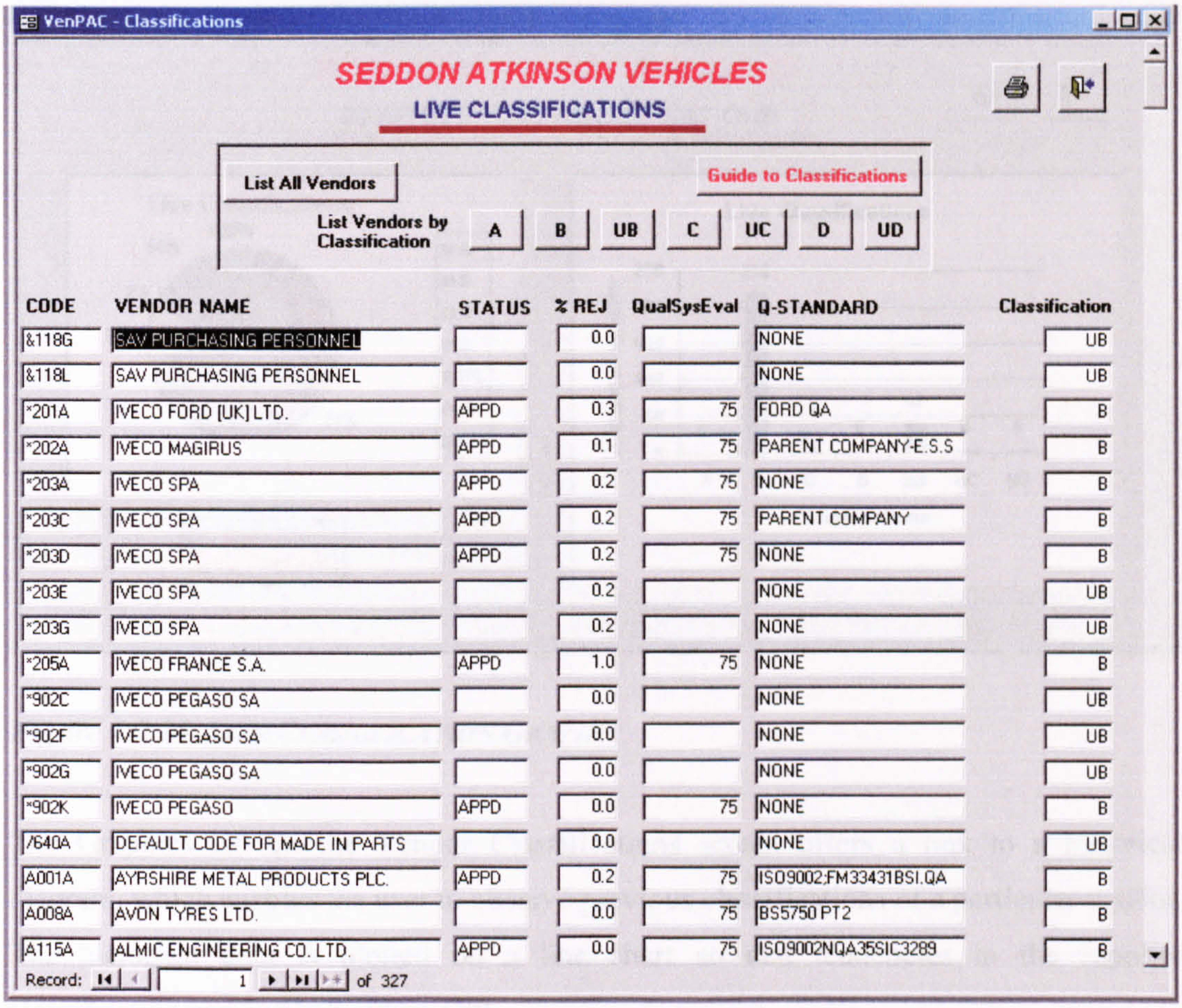


***Figure 6.2.13.* GUIDE TO CLASSIFICATIONS**

The results from the supplier classification appear in the screen called Live Classifications (Figure 6.2.15). The screen offers the facility to sort the current suppliers and to show suppliers which fall into a specific category. A link to the Guide to Classifications and the Supplier Classification Method diagram is also available.



CODE	VENDOR NAME	STATUS	% REJ	QualSysEval	Q-STANDARD	Classification
&118G	SAV PURCHASING PERSONNEL		0.0		NONE	UB
&118L	SAV PURCHASING PERSONNEL		0.0		NONE	UB
*201A	IVECO FORD (UK) LTD.	APPD	0.3	75	FORD QA	B
*202A	IVECO MAGIRUS	APPD	0.1	75	PARENT COMPANY-E.S.S	B
*203A	IVECO SPA	APPD	0.2	75	NONE	B
*203C	IVECO SPA	APPD	0.2	75	PARENT COMPANY	B
*203D	IVECO SPA	APPD	0.2	75	NONE	B
*203E	IVECO SPA		0.2		NONE	UB
*203G	IVECO SPA		0.2		NONE	UB
*205A	IVECO FRANCE S.A.	APPD	1.0	75	NONE	B
*902C	IVECO PEGASO SA		0.0		NONE	UB
*902F	IVECO PEGASO SA		0.0		NONE	UB
*902G	IVECO PEGASO SA		0.0		NONE	UB
*902K	IVECO PEGASO	APPD	0.0	75	NONE	B
/640A	DEFAULT CODE FOR MADE IN PARTS		0.0		NONE	UB
A001A	AYRSHIRE METAL PRODUCTS PLC.	APPD	0.2	75	ISO9002:FM33431BSI.QA	B
A008A	AVON TYRES LTD.		0.0	75	BS5750 PT2	B
A115A	ALMIC ENGINEERING CO. LTD.	APPD	0.0	75	ISO9002NQA35SIC3289	B

Record: 1 of 327

Figure 6.2.14. LIVE CLASSIFICATIONS SCREEN

A suite of reports and graphical representations are automatically calculated showing the performance classification of each supplier or classification group. (Figure 6.2.16: Live Classification Graphic). This data is automatically updated monthly and movements in Vendor classifications are tracked for a 12-month period. Due to the present high number of suppliers, data from the G.R.N. (goods received note) monitor module is used to distinguish between those suppliers who have been used in the last 12 months (referred to as 'live suppliers' and all suppliers.

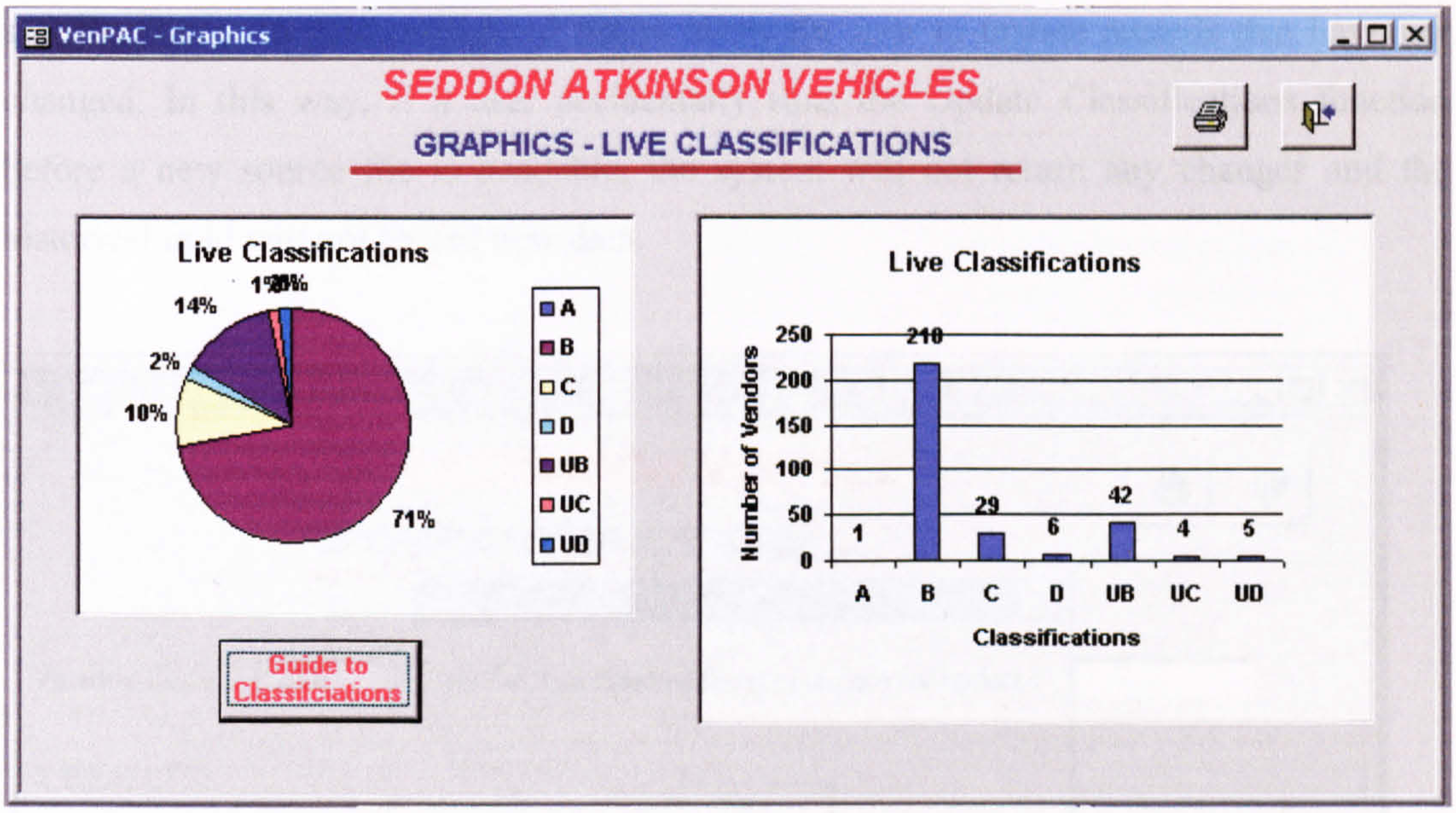


Figure 6.2.15. LIVE CLASSIFICATION GRAPHIC

The Graphics tab on the Vendor Classifications screen offers a link to a historical diagram, which enables the user to observe previous classifications of a particular vendor. The historical data is plotted on a line chart so that tendencies in the supplier classification can easily be identified.

The Reports tab on the Vendor Classifications screen gives a choice of four reports – 45 Worst Vendors by Reject Rate, 35 Worst Lines by Impact Rate, Live Vendor Classification Summary, and Commodity Groups.

The last tab on the Vendor Classifications screen is a facility, which enables the certified user to update the information on the system, thus ensuring integrity between the data fields entered by different users. The system scans the fields, which have recently been updated by the users and re-calculates suppliers' classifications using the most recent data. After this is performed, the system shows a report of all the supplier classifications that need to be updated (Figure 6.2.17). This function is also interrelated with the historical records – they are automatically updated with the newest data. To ensure that one and the same classification is not repeated in the historical record of the particular supplier, the system is configured not to allow the user to update records that have not changed. In this way, if a user accidentally runs the Update Classifications function before a new source file is available, the system will not return any changes and the historical field will not record new data.

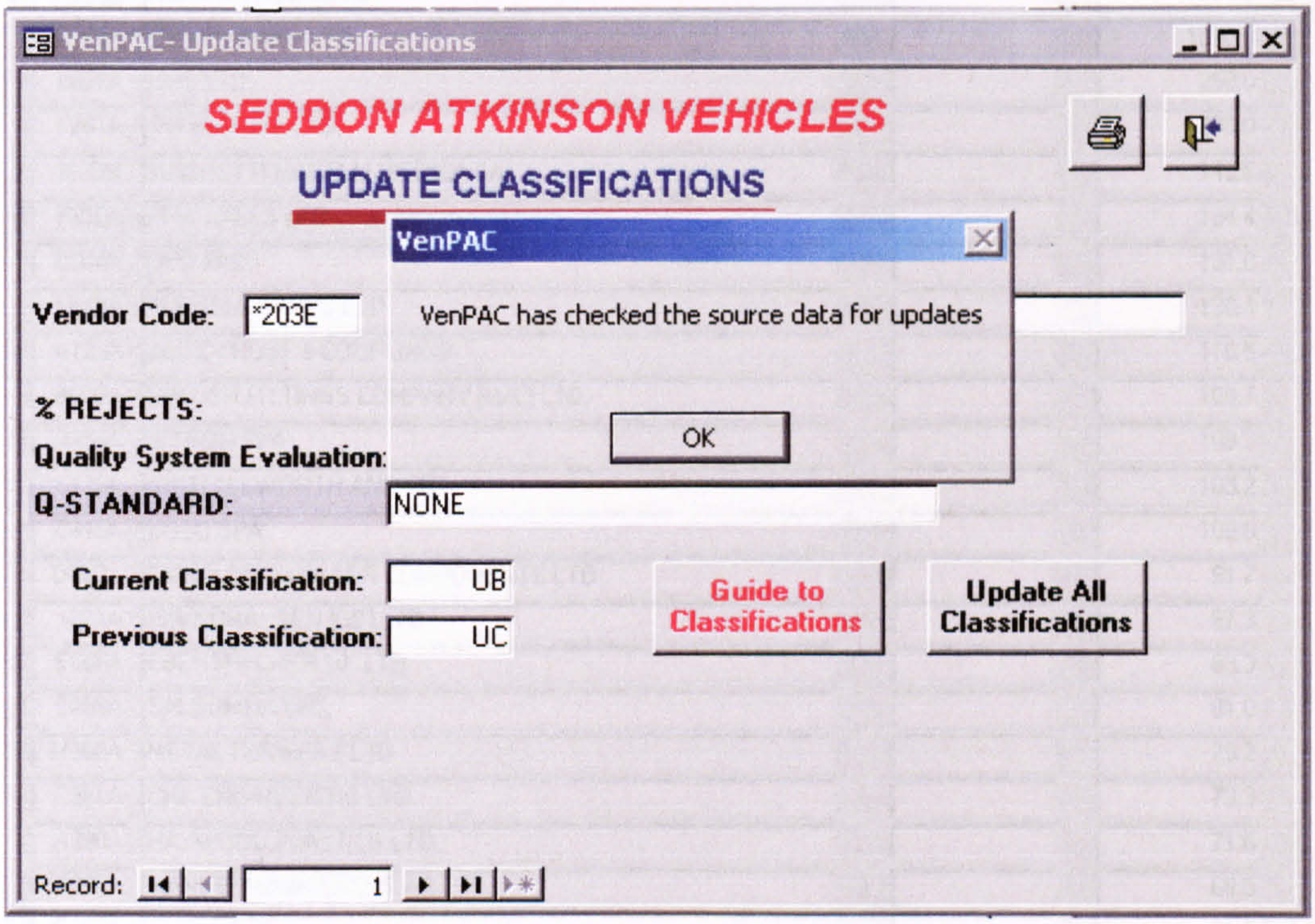
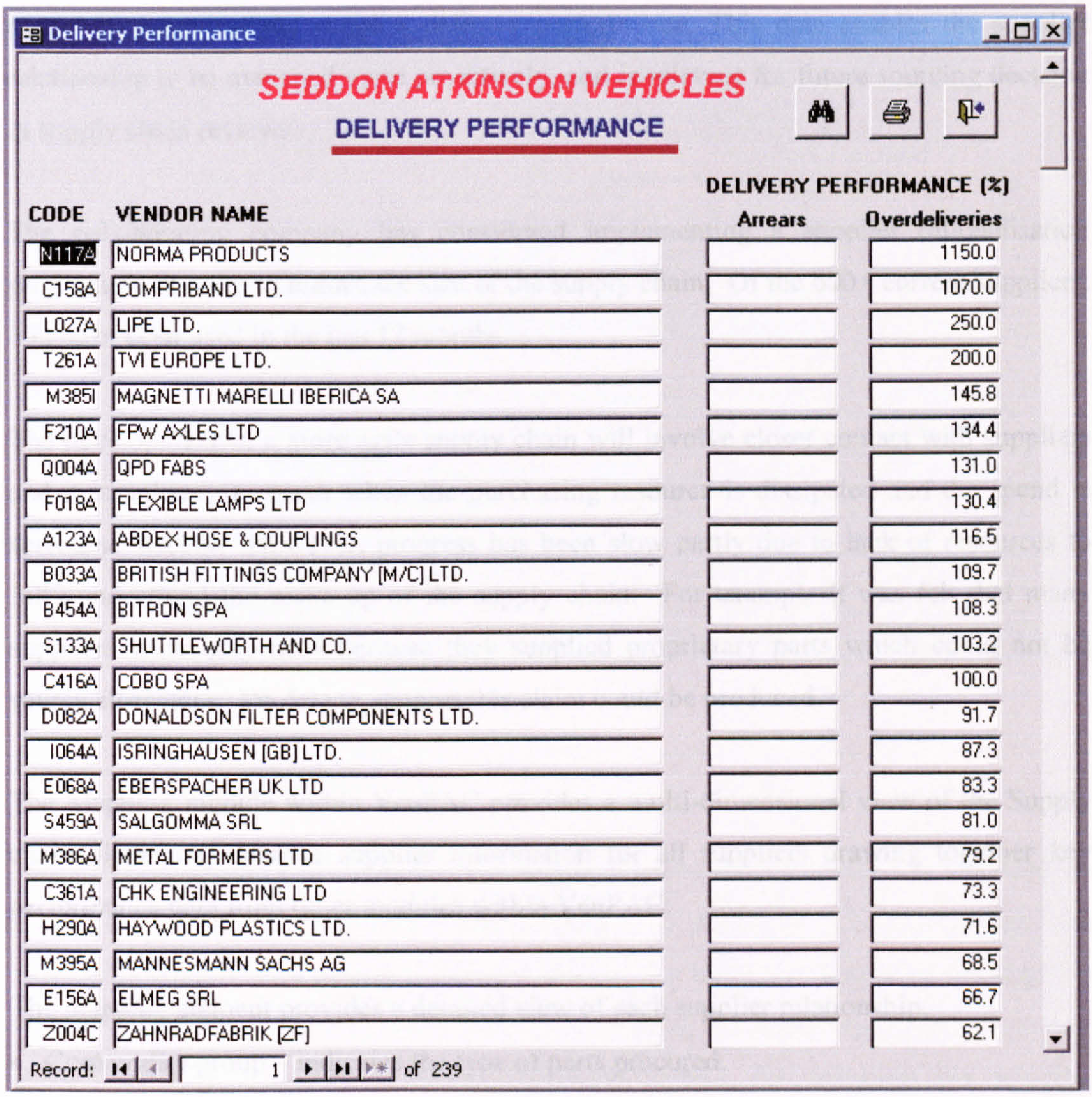


Figure 6.2.16. ***UPDATE CLASSIFICATIONS SCREEN***

Delivery performance is crucial to SAV given its late configuration aspirations and limited ability to plan future requirements due to mass customisation. Before VenPAC was implemented, the suppliers were not downgraded for poor delivery performance. Although arrears were recorded and suppliers who were consistent in underdelivering, overdeliveries were never noted and were actually not criticised. That was a cause of unnecessary capital tied up in inventories and excess usage of storage space. One of the major changes that VenPAC introduced in the delivery performance monitoring procedures at the company, is that overdeliveries are not only recorded but they also reflect the overall supplier's rating.


Delivery Performance

SEDDON ATKINSON VEHICLES

DELIVERY PERFORMANCE

CODE	VENDOR NAME	DELIVERY PERFORMANCE (%) Arrears	Overdeliveries
N117A	NORMA PRODUCTS		1150.0
C158A	COMPRIBAND LTD.		1070.0
L027A	LIPE LTD.		250.0
T261A	TVI EUROPE LTD.		200.0
M385I	MAGNETTI MARELLI IBERICA SA		145.8
F210A	FPW AXLES LTD		134.4
Q004A	QPD FABS		131.0
F018A	FLEXIBLE LAMPS LTD		130.4
A123A	ABDEX HOSE & COUPLINGS		116.5
B033A	BRITISH FITTINGS COMPANY (M/C) LTD.		109.7
B454A	BITRON SPA		108.3
S133A	SHUTTLEWORTH AND CO.		103.2
C416A	COBO SPA		100.0
D082A	DONALDSON FILTER COMPONENTS LTD.		91.7
I064A	ISRINGHAUSEN (GB) LTD.		87.3
E068A	EBERSPACHER UK LTD		83.3
S459A	SALGOMMA SRL		81.0
M386A	METAL FORMERS LTD		79.2
C361A	CHK ENGINEERING LTD		73.3
H290A	HAYWOOD PLASTICS LTD.		71.6
M395A	MANNESMANN SACHS AG		68.5
E156A	ELMEG SRL		66.7
Z004C	ZAHNRADFABRIK (ZF)		62.1

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Figure 6.2.17. DELIVERY PERFORMANCE SCREEN

The VenPAC delivery performance module (Figure 6.2.18) looks at the cumulative orders on suppliers for each part number comparing the requirement with actual deliveries as reported by the Goods received system. Delivery performance is expressed as a percentage for arrears or over deliveries and the information is recalculated weekly. For example, Supplier 'x' cumulative orders of 10 but cumulative deliveries of 5 will show a delivery performance of 50% arrears. Search engine functionality is available to find or sort data according to user defined criteria. It is therefore now possible to quickly access an overview the supplier delivery performance. This data enables the supplier relationship to be managed more proactively, and is relevant for future sourcing decision in supply chain reviews.

The collaborating company has considered implementing a supplier rationalisation programme in order to reduce the size of the supply chain. Of the 600+ current suppliers, 350 have been used in the last 12 months.

The development of a more agile supply chain will involve closer contact with suppliers and it is unlikely to occur when the purchasing resource is dissipated and the spend is spread so widely. However, progress has been slow partly due to lack of resources to fully understand the make up of the supply chain. For example it was felt that many suppliers were only used because they supplied proprietary parts which could not be source elsewhere. No data to support this claim could be produced.

The Mapping module within VenPAC provides a multi-dimensional view of the Supply chain displaying detailed supplier information for all suppliers drawing together key performance data from other modules within VenPAC.

The mapping element provides a detailed view of each supplier relationship.

- Commodity group – indicates the type of parts procured.
- Group indicator – indicates whether the suppliers is a supplier of Group parts, supplier of SAV parts or whether it supplies both.
- Location indicator – indicates the currency in which parts are procured.
- Status indicator – shows the Quality status e.g. approved, pending etc.
- Purchase relationship type indicator – indicates whether the procurement with that supplier is by means of tender, negotiation or alliance.
- Proprietary indicator – indicates whether the company is a single source of supply

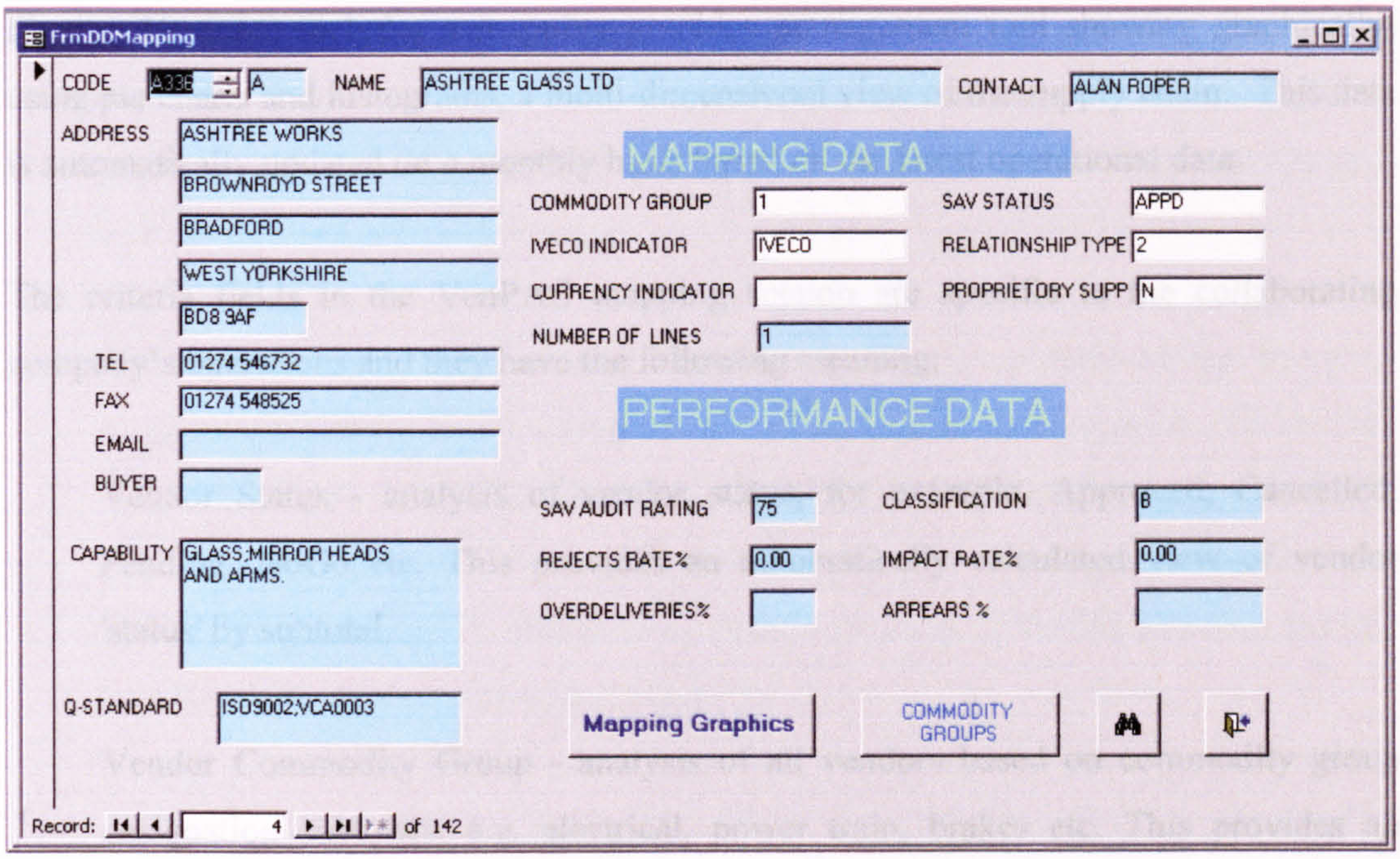

Figure 6.2.18. VENPAC MAPPING SCREEN

The mapping module functionality facilitates efficient data analysis. It provides an excellent management tool to aid understanding of the supply chain assisting with supplier development and rationalisation decisions. An important feature of the mapping module is the user defined search functionality using the mapping criteria described above, see Figure 6.2.19: VenPAC Mapping Screen. By selecting the required combination of mapping elements, VenPAC will search the database 'returning' suppliers matching the selected criteria. For example, find all suppliers in commodity group '16' (electrical) who are 'approved' and have the capability to supply both group and SAV engineered parts. This is extremely useful when locating suppliers for new parts or when re-sourcing parts. It may also assist the development of a rationalisation programme where supplier relationships could be limited to higher quality suppliers who already supply a significant number of lines to the collaborating company.

Finally, VenPAC includes a mapping graphics management tool showing graphically, using pie charts and histograms, a multi-dimensional view of the supply chain. This data is automatically updated on a monthly basis based on the latest operational data.

The criteria fields in the VenPAC mapping section are specific to the collaborating company's operations and they have the following meaning:

Vendor Status - analysis of vendor status, for example, Approved, Cancelled, Pending, NoGo etc. This provides an automatically calculated view of vendor 'status' by subtotal.

Vendor Commodity Group - analysis of all vendors based on commodity group designation subtotals, e.g. electrical, power train, brakes etc. This provides an automatically calculated view of the number of Vendors supplying each commodity group category, for example, how many vendors currently supply 'consumable' parts.

Vendor IVECO Status - this provides an automatically calculated view of suppliers' capability to supply parts originating from different engineering functions within the group.

Proprietary Part Vendor Indicator - analysis of all vendors based on an interpretation of the generic or proprietary nature of the parts supplied. This provides an automatically calculated view of the extent to which 'Customer' or 'Engineering' driven decisions relating to proprietary parts are influencing the size of the supplier base.

Relationship Indicator - analysis of all vendors based on the nature of the purchasing relationship, for example, Tendered, Negotiated or Partnership.

Lines Supplied Indicator - analysis of current vendors based on the number of lines supplied. E.g. 1-10, 11-25, 26-50, 51-100, 101+. This provides an automatically calculated view of depth of relationship with Vendors. It should be noted that cost implications are not considered.

Categorisation of Y.T.D. current value of business - analysis of the levels of business per Vendor based on year to date spend pattern categories £1 - £500; £501 - £5,000; £5,001 - £25,000; £25,001 - £100,000; over £100,000. This provides an automatically calculated view of depth of relationship with vendors based on the leverage and relationship that it is possible to develop. It should be noted that the number of lines purchased is not considered.

6.2.4 SUMMARY AND CONCLUSIONS

This section of Chapter 6 presents the development and implementation of a low cost database tool, designed to provide a computerised environment for effective supplier management in the SME automotive sector. It shows the importance of data visibility using a familiar user-friendly tool to aid decision-making for both supplier monitoring and supplier selection. The purpose of the system is to make the various processes more transparent as a first stage in problem identification and problem solving. This is achieved by providing data visibility and automating analysis, which would be beyond the resources of most SME's.

This case study demonstrates how the system has been successfully implemented in a truck manufacturer emphasising the importance of supplier relationship management. As a secondary issue, this chapter also shows that MS Access, a widely available and affordable application can be used to develop a moderately sophisticated tool for use in the management of suppliers. This is an important aspect and would benefit many SME's as most of them already have MS Access.

The case study achieved its initial objective to confirm what had already been found from the literature review – that although well established best practices are available, companies in the SME sector rarely implement them and even less often use them to their full efficiency. A well developed supply chain management tool, in the sense defined in the literature review, was not being used by the company, besides that, management was not aware of a commercial availability of any tools that would help them address their supply chain management problems.

One possible explanation of the situation can be the size of the company, another is the lack of strategic planning of its supply chain which results in overlooking the importance of each key element of the supply chain for its efficient functioning. Before the development and implementation of the system, management wrongly assumed that supply chain management tools are expensive systems which are only affordable by large organisations with a lot of funds available for investment. The literature encourages that wrong assumption by stressing the elaborate nature and the expense involved in implementing a supply chain management system. That is why the management of SAV had automatically excluded the possibility of finding, or even designing, a supply chain management system which is affordable to them and addresses their specific needs. The case study proved that that misconception can be easily overcome once the concept of the tool is presented to the management and its features, ease of use and usefulness are demonstrated to them.

The case study proved that a supplier relationship management tool was necessary for the management to get to grips with the company's supplier base – without such an analytical tool, it was practically impossible for anyone within the company to have a good knowledge of what the supplier base represented and even less knowledge of tendencies and trends in the suppliers' performance, let alone be able to manage effectively and efficiently the relationships with the numerous suppliers.

Another finding which resulted from the case study was that the implementation of a bespoke system not always involves a lot of time, effort and expense. Especially with small companies where the systems are used by a limited number of people, it proves to be a much more cost-effective solution since readily available database software, such as MS Access, can be customised with moderate efforts and basic programming skills in order to achieve the desired functionality. Implementation and training is also easy as the software is designed with the help of the users themselves and the functionality is fit for their needs and level of computer literacy.

The case study has confirmed that dispersed non-interconnected systems used throughout the supply chain, coupled with the traditional "over the wall" approach, have caused tremendous loss to manufacturers in terms of information available for decision making, resulting in loss on terms of re-work, scrap, and materials and labour wastage. Bespoke systems can be used to bridge the gap between different functional areas and different information systems within the company in order to bring information together and analyse it so that it can be presented in a summarised, systematic way to the decision maker.

Companies with an extensive supplier base, such as the case study company, need a systematic way of classifying their suppliers and automatically selecting the most appropriate one for their particular needs, often as part of a supplier-reduction programme. A software tool can do that easily, provided that its logic is based on a carefully thought-out supplier selection strategy. The case study company did not have a system of its own for classifying its suppliers. The researcher provided a useful classification system, having contacted Iveco and studied the supplier selection process practiced by them. A decision was made to adapt their supplier management system to the needs of SAV – this proved to be extremely beneficial in that the new system was compatible with the Iveco system – from now on, the two companies could easily use each others' supplier base as suppliers were readily assessed and classified so that additional enquiries and surveys would not be necessary. The latter proves the benefit from synchronising supply chain management practices within the whole supply network. In that way, the different participants can use each other's resources, avoid unnecessary handling of information and in general, communicate in one and the same supply chain 'language'.

6.3 CASE STUDY 2: PROCESS MAPPING AND SIMULATION OF SHOP-FLOOR OPERATIONS AT CHASE-AT

6.3.1 INTRODUCTION TO CASE STUDY 2

The second case study that was undertaken as part of the research looks in detail at the shop floor processes of a medium-sized electronics manufacturing company, Chase AT. At the beginning, it was intended to look at the whole supply chain of the company and to avoid focusing on just one of its supply chain areas but, during the course of the research, the objective proved impossible to achieve. Information about the suppliers and customers to the business was not available in sufficient detail. As a result, it was necessary to focus on studying the shop floor operations at the company and how they affect the competitive position of the company in the marketplace. Process mapping and process flow simulation exercises were undertaken within the case study company to help the researcher gain deeper insight into the processes on the shop floor and how they are effected by changes in the supply chain. Since the manufacturing process is a major part of the supply chain, getting to know it better would help produce more valid conclusions relating to the supply chain as a whole and more accurate picture of what tools and methods are available for managing the supply chain in its entirety.

The above made it necessary to define the case study objectives more precisely in order to achieve the research aims. The case study work started with familiarisation with the company, its marketplace, financial situation, management structure and corporate culture. In order to find out what the current manufacturing practices on the shop floor are, it was necessary to carry out a detailed process mapping of the operations at Chase AT. The resulting maps and their analysis helped answer the question what tools and methods were currently being used by a manufacturing company to manage the manufacturing part of its supply chain and how effective they were. The case study continued by using the collected data for building a simulation model. Using the simulation model of the process flow, a number of various set-ups were run to demonstrate the benefit from using simulations for improving shop floor layout, process sequencing, buffer zone allocation, operator scheduling, etc. The simulation also helped draw conclusions about the importance of modelling and simulation tools and their implications for the management of the company and its positioning in the entire supply chain. The case study also uncovered the inefficiencies of the available tools and techniques for modelling, analysing and improving the manufacturing operations of different agents in the supply chain.

6.3.2 THE CASE STUDY COMPANY AND ITS SUPPLY CHAIN

Chase Advanced Technologies was established in 1989 by Dr. Anthony Martinez to provide contract-manufacturing services offering a full turnkey solution for the manufacture of electronic products on a sub-contract basis.

In 1996, the company suffered a major loss of customers. This loss was attributed to a number of factors. A major increase in business levels had led to the company recruiting large numbers of staff, but local employment market constraints meant that the majority of this new staff was unskilled. The consequence of this was a decline in quality and so a major loss of customers.

1997 saw the appointment of Eugene Martinez as Managing Director of the Manufacturing Division and a reorganisation of the company based on Goldratt's Theory of Constraints (TOC). This coupled with a substantial investment in training turned the company around.

The Contract Manufacturing Services Market is estimated to be worth 115bn USD worldwide, with the UK estimated to be worth 7bn USD and growing at a rate of 15%. Chase AT's Contract Manufacturing base spans diverse sectors of the market to include security, industrial controls, fibre optics, communications, satellite receivers, audio equipment and PC peripherals. The core customers operate in the technology, telecommunication and multimedia market.

At the time of the case study, Chase AT had three principal customers: Filtronic, Emco Electronics and Minibar.

Chase AT dealt with two parts of Filtronic - Filtronic Comtek and Filtronic Broadband Ltd. They were Chase AT's number one client and the company put a high priority on meeting their demands. Filtronic provided regular forecasts to Chase AT, which allowed the company to plan production of these products thirteen weeks into the future and secure material for the order. There were, however, a number of problems with this forecast, the main one being that Filtronic did not stick to it. A second problem with this forecast was that it did not provide due dates for the product. Filtronic were supposed to provide the forecast every Tuesday but this did not always happen, in some instances the schedule was known to arrive as late as Friday. The situation was made worse by the fact that Filtronic operated a closed-door policy and so it was difficult to get information from them. Chase AT felt that if a change was for the benefit of Filtronic, Filtronic would cooperate but if they were not directly interested, communication was slow.

In an attempt to improve the company's competitive position and resolve some of its problems, the MD introduced TOC in Chase AT in 1996. He began trying to introduce the concepts himself changing things gradually. The idea was to change the culture of the company throughout. The introduction of TOC demanded change in the whole of the manufacturing environment, from machine layout to batch size. This is demonstrated when the Surface Mount (SMT) procedure was looked at. The SMT process is the first procedure a circuit board passes through after it leaves kitting. The procedure begins by the printing of circuit boards using glue or solder. The board is then placed in the SMT machine and components are placed on it. Prior to the introduction of TOC, the entire batch of boards was printed and then passed on to the SMT machine which resulted in a number of quality issues within this area. The new system set up the printing machine next to the SMT machine and placed a quality inspector at the end of the SMT machine. Now each board is printed, checked by the operator, labelled and placed in the SMT machine. The board leaves the SMT machine and passes directly to the quality inspector. The whole process now only requires one operator who passes between the printing machine and the SMT machine. Since each board is essentially a batch of one, any non-conformance is detected early and problems are solved quickly.

Another change made after throughput analysis was the introduction of buffers in a number of areas on the shop-floor. This was done after the constraints of the system were identified. Buffers were introduced before Post-flow and before Test as these manufacturing stages were identified as bottlenecks.

6.3.3 PROCESS MAPPING AND SHOP FLOOR SIMULATION

In order to develop a better understanding of the case study company and its operations, the author undertook to carry out a process mapping exercise. This had the objective to demonstrate whether the shop floor operations are organised in a manner that would be appropriate for the particular company and its environment. Process mapping was expected to provide sufficient insight into the operations of the company in order to assess the fit between its operations and its strategy. The process of data collection and mapping took the better part of the time allocated for case study 2 but it helped reach some important conclusions regarding the significance of careful strategy formulation for the success of the company.

Following the process mapping exercise, the researcher felt that a simulation of the shop floor activities, based on the already collected data and using different layout and manufacturing organisation models, would contribute to the conclusions that followed from the process mapping. In simulating various scenarios on the shop floor, the researcher intended to demonstrate what an advanced SCM tool could highlight as viable (and potentially, more successful) decisions regarding the manufacturing strategy.

The remainder of this section will describe the processes of data collection, process mapping and shop floor simulation that were carried out during the case study period.

INITIAL DATA CAPTURE

Prior to the start of the work on the case study, a meeting was held with the Operations Director at Chase AT to discuss the requirements of the company and to establish a project brief. The aims of the meeting were to a gain a basic understanding of the company, ensure that the problem is defined correctly, and establish the level of detail required. The meeting also aimed at identifying the available sources of information, namely: employees at all levels within the company, Quality Manuals, and formal process definitions. It was identified that detailed data capture needed to be carried out at the beginning of the project which was to serve as the basis for process modelling and shop floor simulation.

Data capture was carried out using one to one interviewing. Loosely structured open questioning was used to obtain information. Managerial staff were interviewed first to deduce an overview of the company and gain an insight into company procedures. Interviews with the managerial staff were carried out in the company's conference room. Interviews with shop floor personnel were carried out either on the shop floor or in the company canteen. The main reason for this difference was to ensure that all interviewees were comfortable in their surroundings and did not feel in any way intimidated. The interviewer introduced herself and informed the person being interviewed of the project and its desired outcomes, the interviewee was assured that they were welcome to ask any questions at any time.

Notes were taken during each interview and validated. The initial validation was done by repeating the information, as it was understood, back to the interviewee and asking them if this was correct. After the meeting notes were converted into a flow chart and shown to the interviewee, asking them to again validate the information.

All the obtained data was formalised using flow chart methodology. This allowed areas lacking in data to be identified and highlighted any discrepancies. Second interviews were carried out with some of the employees depending on the problem area and further information obtained.

OVERVIEW OF PROCESS MAPPING AND SHOP FLOOR SIMULATION

Before the data would be put into practise, it was necessary to explore the available methods for process modelling. Therefore, the researcher undertook a detailed literature review which served to outline the required theoretical understanding. A brief description of the techniques that were utilised in the research process follows.

The process of building a supply-chain simulation model provides valuable insights and understanding of the behaviour and characteristics of a supply chain. Beyond this expanded knowledge, however, most models are developed to address particular issues. Types of issues that can be addressed using simulation generally fall into the following categories [Kindred, 2002]:

- **Optimisation**: Optimisation usually involves finding the optimal operational guidelines that either maximize or minimize a particular result, such as minimizing costs and/or risks and maximising profits.

- **Decision Analysis**: Decision analysis typically involves the quantitative evaluation and comparison of two or more alternatives. For example, the decision to build a new production facility could be evaluated by simulating how the supply chain would be impacted by the additional facility. Alternatively, the analysis might be focused on comparison of ten different locations for a new production facility.

- **Diagnostic Evaluation**: Diagnostic evaluation is typically conducted when the cause of a particular problem is unknown. Supply-chain simulation can provide insight into the cause of the problems and facilitate development and evaluation of various solutions.

- **Risk Management**: Supply-chain dynamics can be severely impacted by unanticipated disruptive events. Many corporations are attempting to determine how to prepare themselves for such events. Supply-chain simulation can provide an important role in helping companies design redundant systems or mitigation plans to minimize the impacts of disruptive events.

- **Project Planning**: Changes to a portion of the supply chain can result in major disruptions and short-term or even long-term inefficiencies. In contrast to decision analysis, which is focused on whether to implement a project, project planning is focused on implementation of the project in a manner that minimizes cost, stays on schedule, and minimizes potential risks.

Successful development of a supply-chain model is similar to any IT project in that the greatest benefits are received when development is planned and executed by knowledgeable technical experts following a well-practiced methodology. Most successful methodologies include the steps shown in Figure 6.3.1.

This general methodology illustrates an iterative top-down process, rather than a straight-line process. The primary advantage of the top-down approach is that greater detail is only added in areas that govern performance of the system relevant to the issue at hand. In this manner, important results and return on investment are provided as quickly as possible. The model can be expanded in additional areas as the focus shifts to other issues. Development of the computer model typically involves the following steps:

1. **Define Objectives**: Defining the objectives is a critical first step in any model development process. With regards to supply-chain modelling, it is important to identify how the model will be used in order to determine the scope and breadth of the simulation model. Defining objectives must involve the project collaborator, decision makers, and the researchers, building the model.

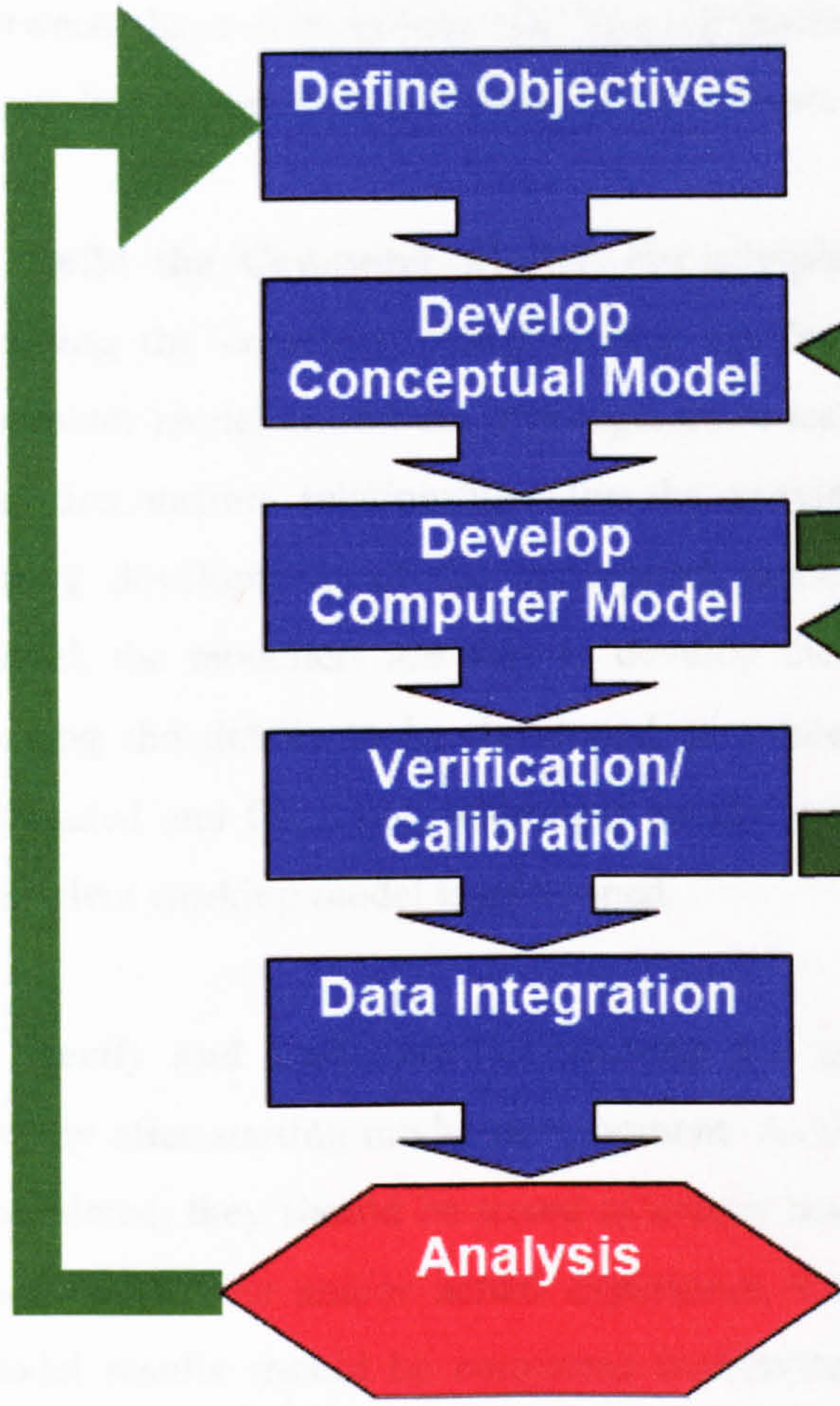

Figure 6.3.1. *SIMULATION MODEL DEVELOPMENT PROCESS (BASED ON THE AUTHOR'S SUMMARY)*

2. **Develop the Conceptual Model**: Building a conceptual model of the supply chain is probably the most important part of the entire exercise. This phase typically involves input and feedback from many people within the organization and thoughtful investigation of how the different elements of the system relate. Most people find that the exchange of information and ideas while formulating the conceptual model results in valuable insights and better understanding of the supply-chain system prior to even building a simulation model. In addition, the conceptual model building phase provides a critical opportunity to get support from a broad range of members of the organization (e.g., operational managers, supply-chain experts, senior management). The conceptual model should identify all the important components of the model (production facilities, suppliers, distributors, inventories, etc.) the critical relationships

between these components, the flow of materials and information, and the critical input data and metrics that govern system dynamics and drive decision-making.

3. **Build the Computer Model**: For complex systems, it is preferable to begin building the computer model during development of the conceptual model. The computer model allows the investigators to test components of the conceptual model and demonstrate relationships, thereby providing valuable insight and perspective during development of the conceptual model. By using a top-down hierarchical model, the modellers are able to develop the overall structure of the model while leaving the details to be developed at a later stage. As the conceptual model is expanded and filled out, additional details are added to the computer model until a complete working model is developed.

4. **Verify and Calibrate**: Verification and calibration of the model should begin shortly after starting model development. As components of the computer model are completed, they should be tested to ensure that the model results are consistent with expected results and/or actual experience. Once the computer model is complete, model results should be compared with historical results to verify that the model captures the behaviour of the supply chain. Typically, the verification process will require calibration of some model parameters to achieve a close match with actual results. Verification should be conducted any time the model is significantly modified or updated.

5. **Data Integration**: For complex supply-chain models with a large quantity of input data, it is much more efficient to have the computer model retrieve the appropriate data from databases containing the latest information. In some situations, this information can be obtained directly from corporate ERP systems. In other situations, however, it may be necessary to conduct post-processing of the data before the information is suitable for use in the supply-chain model.

A computer simulation is a conceptual model of a manufacturing environment. It can be used to improve manufacturing performance by enabling the user to alter the possible variables within the system and to view the effects of these changes. In order to build such a realistic simulation, one must be familiar with the system to be simulated. The information which is required for the simulation is captured using a number of techniques and used to produce a model. [Perera and Liyanage, 2001]

Perera & Liyange have identified a number of problems that can arise when carrying out data capture. In order to produce an accurate report of the business it is necessary to identify these issues to prevent them from affecting the validity of the model. [op.cit.]

One issue that arises when a project such as this is carried out is incorrect problem definition. It is essential to have a good understanding of the nature and scale of the problem. This forms the foundation of the project and if not achieved can lead to a lack of clear objectives. The poor definition of objectives can affect the scope of the model leading to inappropriate data collection.

It should be noted that the variety and volume of data to be collected is directly related to the complexity of the system under investigation. The more complex the system, the greater the amount of data is that must be collected. This in turn means that unless correct problem definition occurs and clearly defined objective are set, there is a greater chance of problems occurring.

The level of model detail should also be established prior to the actual data collection. Modelling of higher levels of detail does not necessarily lead to higher accuracy and comprehension but can lead to longer data collection. Too much information can result in the actual problem being ignored and real issues being clouded.

One final problem, which arises, is identifying available data sources. It is difficult to identify reliable data sources due to the existence of multiple data sources for some data types and the indirect existence of data.

A model is a simplified representation of reality and is often pictorial, it is used to document a certain situation and present it unambiguously. Modelling allows us to understand and explain systems thus providing good visibility for improved problem solving. Models should be constructed in such a way as to highlight, or emphasise, certain critical features of a system, while simultaneously de-emphasising other aspects of the system. They should divide problems into layers thus allowing solutions to all problems to be developed concurrently.

Modelling tools allow one to focus on the important factors within the system. They provide a basis for discussion and allow changes and corrections to be made to the user's requirements with low cost and minimal effort. Models allow one to establish whether the analyst has fully understood the user's environment and require that it be documented in such a manner as to allow the simulation designers and programmers to build the simulation. Modelling formalisms allow one to build models according to a set of associated concepts.

For the purposes of modelling in the present case study project, the researcher used methods that she had used in her past work and had found most successful.

PROCESS MAPPING

After the interviews and data collection were carried out, the results were summarised into a concise overview of the company. The interviews helped understand the following specificities of the company and its environment. The business of circuit board manufacture is split into two distinct areas. As is the case with all manufacturing, there is a planning element and a manufacturing element. The planning element is carried out in the offices to the back of the Chase AT building and is split off from the factory by a glass screen through which the shop floor is clearly visible. Employees move freely between shop floor and office and vice versa.

The business of Chase AT begins with order intake, passes to purchasing, goods receiving and on to planning. These processes are not sequential; they interact at many different levels.

Order Intake & Purchasing at Chase AT

The team responsible for order intake consists of eight people: four Engineers, the Engineering Manager, the Process Engineer and two Document Controllers. This is the initial stage and the point at which orders are accepted and PCB (Printed Circuit Board) design carried out.

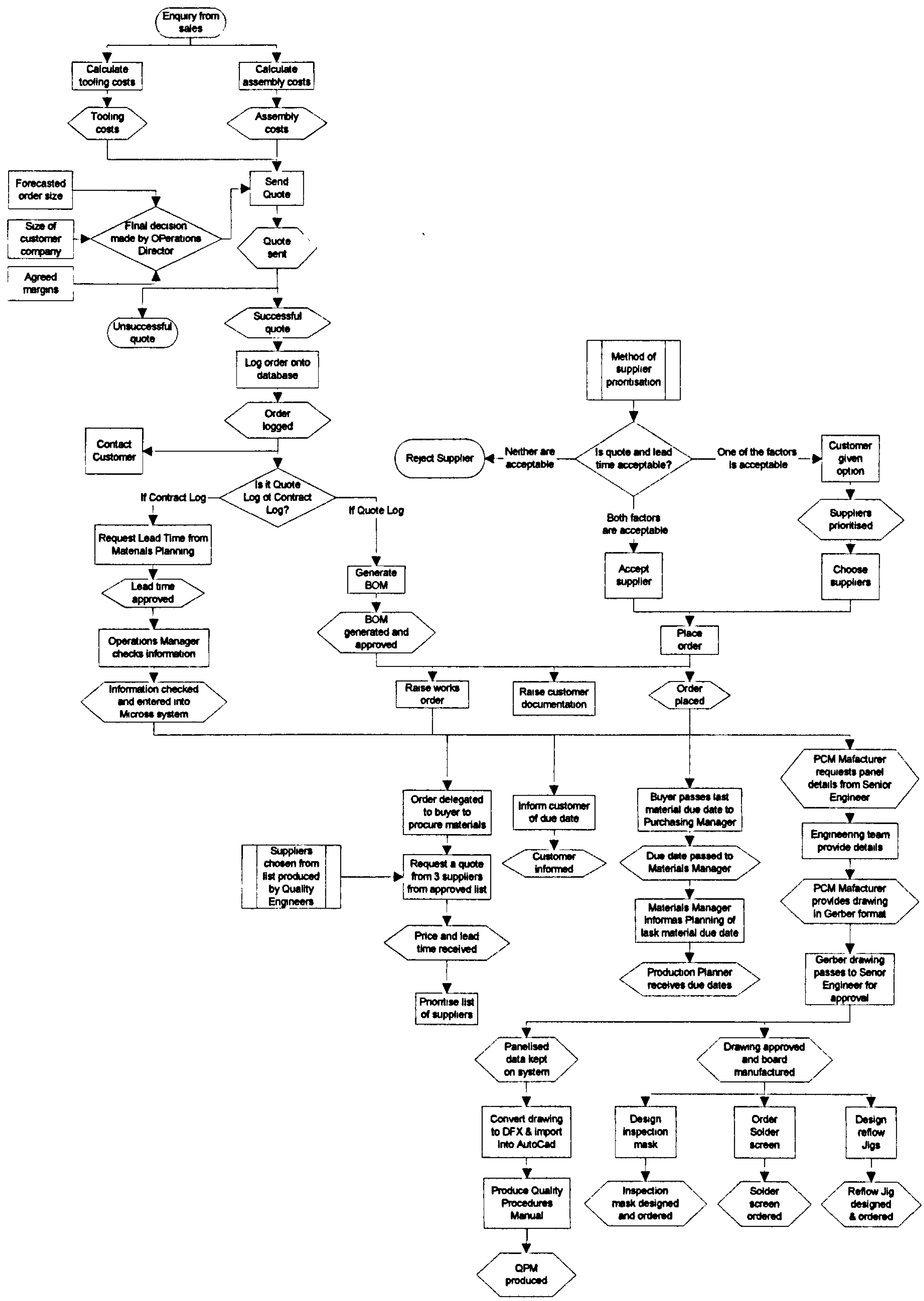

Figure 6.3.2. ***DFD OF PRE-PRODUCTION PROCEDURES AT CHASE AT***

Purchasing deals with costing, expediting and accounts acquired. Four people work within the purchasing team. The Materials Manager heads the team and is the main link between purchasing and the planning department. Each of the other three members or buyers deals with their own delegated customers.

The data flow diagram (DFD) in Figure 6.3.2 models all the procedures that are carried out prior to production. It can be seen that there is no defined line between order intake and purchasing. Information flows in both directions and the two areas operate synchronously.

The sharing of information can be seen from the onset of order intake. Calculation of costs, although carried out using a computerised spreadsheet, requires input from the purchasing department.

The DFD shows that there are different procedures for quote and contract logs. A quote log, being a new order, requires the development of the PCB design and Quality Procedures Manual (QPM). The DFD clearly shows the complexity of the process and the linkages between various points within the procedure.

Production Planning at Chase AT

The Operations Manager carries out production planning. He is responsible for the whole process from order intake through to despatch. The Operations Manager is also the main point of customer contact and most decisions made in this area are based on customer requirements. The production plan is made weekly and updated daily. The plan is driven by customer requirements, procedural knowledge and resource availability. Much of the production planning appears to be based on previous knowledge of the system.

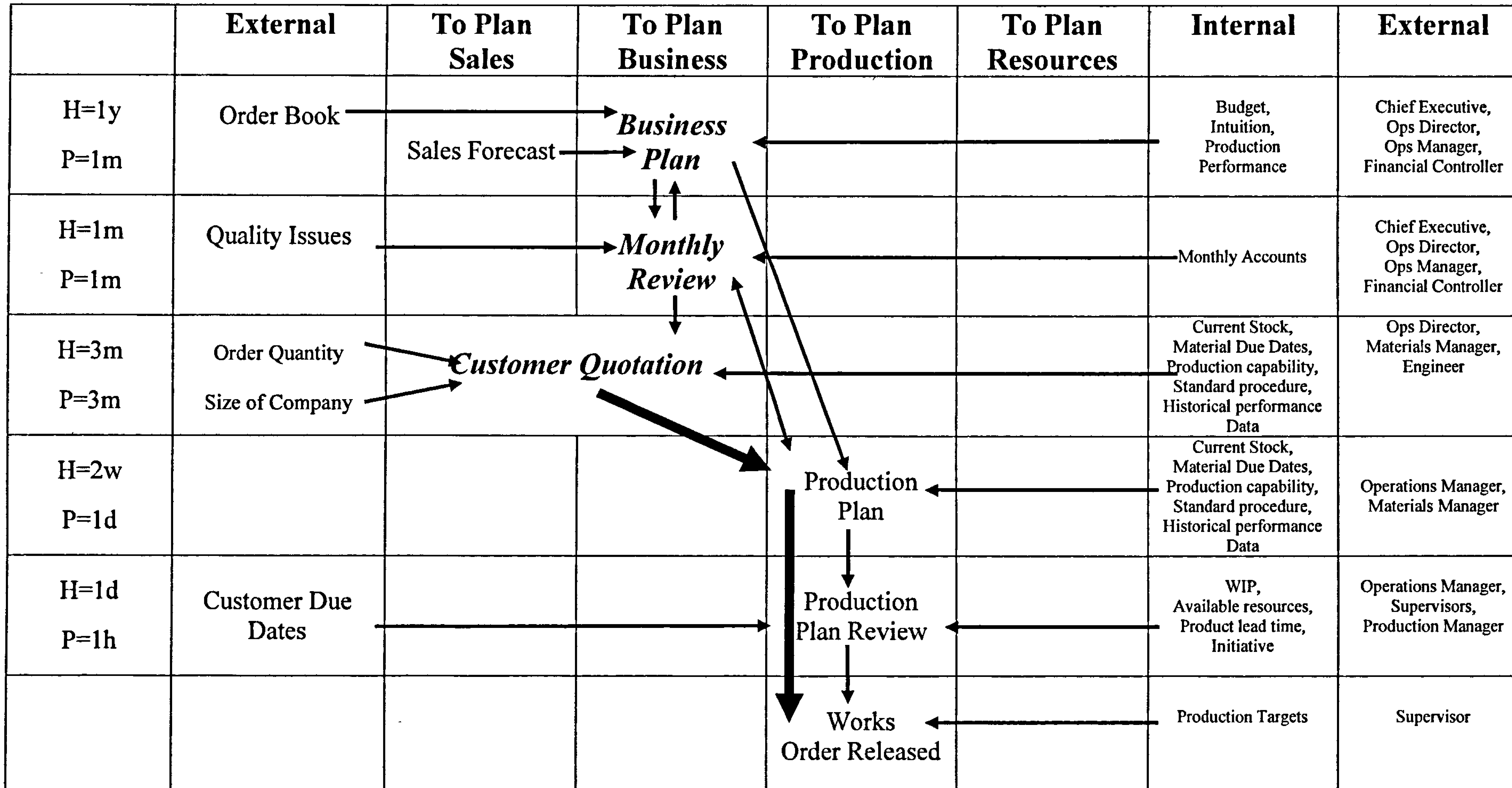

Figure 6.3.3. ***GRAI GRID OF THE BUSINESS PROCESSES AT CHASE AT***

Figure 6.3.3 shows a GRAI grid of the business processes at Chase AT. From this GRAI grid it can be seen that production planning is at the heart of all the decision-making processes. A production plan is produced every week and spans a period of two to three weeks depending on the types of order. Micro adjustments to this plan are made hourly. At any one time 20 types of product are being produced on the shop floor. Assessing resource availability is therefore not a simple task since knowledge of each procedure and timings for each workstation must be known.

Forecasting is another important input into the plan and is also used to calculate resources availability. The forecast is made to judge the capacity required at given points and is only made for certain clients such as Filtronic.

Material availability and machine availability are the other inputs required to calculate total resource availability. The assessment of resource availability in production planning is essential. Under allocation of resources will result in missed due dates and over allocation will result in the inefficient use of resources.

Customer priority is another important factor influencing production planning. High priority customers are those that place the largest orders most frequently. Currently Filtronic is highest on the priority list. Orders from high priority customers are scheduled first. Last minute amendments to the production plan are usually as a result of a request from Filtronic.

Knowledge of the procedures involved in the production of PCBs is the key to good production planning. Figure 6.3.4 contains a diagram showing the complexity of product pathways on the shop-floor. It is evident from this diagram that controlling production of all the products on the shop-floor is not a simple task. The production planner must be aware of the type of board, the processes that specific board must go through, the number of components to be placed per board and the speed of placement of components at each machine or workstation.

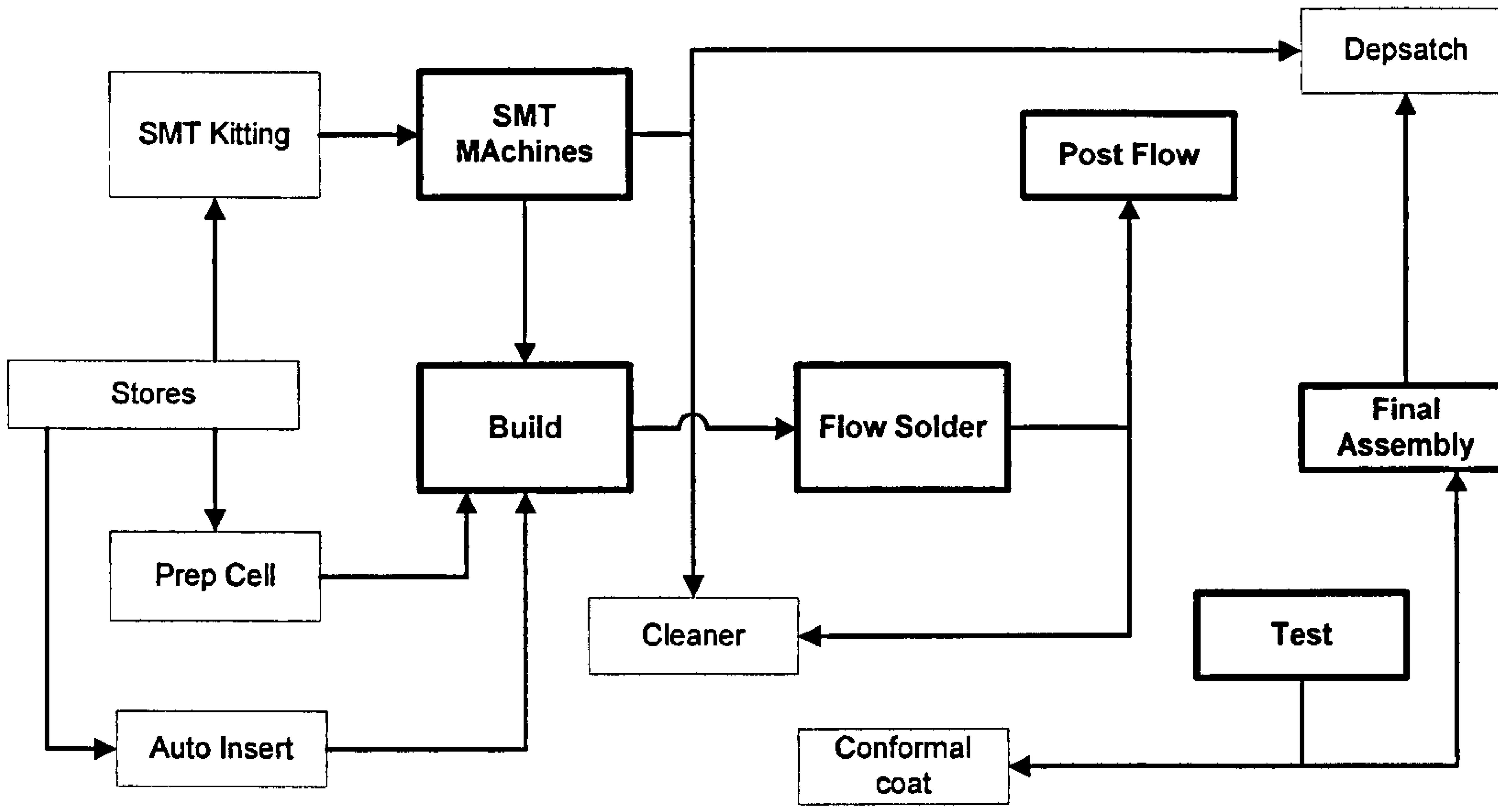

Figure 6.3.4. ***DIAGRAM SHOWING COMPLEXITY OF PRODUCT PATHWAYS ON THE SHOP FLOOR***

The factors discussed are internal inputs into the production plan. The only direct external factor is customer due date. This day of delivery is decided in relation to the customer but it is not accurate to call it a due date. It is more appropriate to say that Chase AT sets delivery windows rather than strict dates. The setting of a delivery window is favourable for the customer rather than for Chase AT. It should be the case that this method benefits production planning, allowing them to set a due date and level resources within slack. In reality this does not happen and the production plan is altered at the last minute to accommodate the customer. Thus the plan is not taking full advantage of the delivery window.

Production planning at Chase AT is influenced by the factors set out in the GRAI net in Figure 6.3.3 but planning and scheduling are not carried out in a formalised manner. It relies solely on the expertise of the Operations Manager. The company already has a basic project management tool but it is not used to its full advantage.

Surface mount kitting involves the bringing together of all the components and the instructions (the Quality Manufacturing Procedure – QMP), required to complete the batch. The operator then places all surface mount components, which are on reels, onto a feeder that is pushed into the surface mount machine. The feeder is programmed with part numbers, batch size and the works order number. This phase of the process takes approximately 1.5 hours and is carried out by one operator. To ensure that all work has been done correctly, the operator uses a process checklist.

SMT is the second phase of the process and involves the printing of the electronics board (PCB) with solder. Each PCB is printed individually and then placed in the SMT machine, which positions all the surface mounted components. Prior to operation the machine has to be digitised to give it the co-ordinates of the PCB. The PCB is checked against the QMP and the Bill of Materials (BOM) to ensure all components are correct and in the right places. It is then passed through the oven. For a batch of 1000 boards, this whole process takes 10 hours. One operator carries out all the procedures involved.

The Axial phase of the process involves the placing of axial components such as diodes and resistors by the axial machine. The machine is programmed with instructions from the QMP and then auto adjust is used to align the PCB. The machine then places all axial components. The PCB is checked by the operator and labelled to show this. The process is carried out by one operator and for a batch of 1000 it takes approximately 4 hours to complete.

The build stage involves four people and for a batch of 1000 takes 5 hours. In this stage of the process, the first three operators place components by hand on the PCB, as dictated by the QMP. The fourth operator acts as Quality Control and carries out a Quality Audit. All components are checked against a process inspection record.

The fifth stage, through which the product passes, is flow solder. During this stage, the PCB is checked to ensure all the components are correctly seated, metal strips are applied to the PCB and it is placed in the solder bath. After the PCB has passed through the bath it is checked against the QMP. Each PCB takes about 3 minutes to pass through the bath and on average 5 PCBs are in the machine at one time. This stage of the process is directly linked to Build as each PCB is flowed as it is built.

This means that rather than wait for the whole batch to be completed and then flow it, the PCB is passed straight to the flow solder operator by the quality auditor. Modelling this scenario would be complex so, for the purposes of this case study, the time quoted for build also includes the time to flow the entire batch. Thus for a batch of 1000 '1 Up Inverters' the time taken to build and pass through flow solder is five hours.

Postflow is split into two stages. First, the PCB is broken into separate boards, and then the board is checked for missing components or dry joints. One person splits the boards and the remainder of the boards are divided between two people. The batch spends 5 hours in Postflow.

After Postflow, each board is checked to ensure all components are in working order. One operator tests the entire batch and on average it takes 15 seconds per board. This means that a batch of 1000 takes four hours and ten minutes to test.

After the boards have been completed, they are sent to despatch to be packaged and shipped to the customer.

The IDEF models in Figures 6.3.5 to 6.3.13 show all the factors that influence the production of the "1 Up Inverter." From this model, it can be seen that the trigger at every workstation, except for despatch, is the prioritisation of products. This is carried out every time a new product is to be placed on a new workstation. This is validated by the flowchart in Figure 6.3.14.

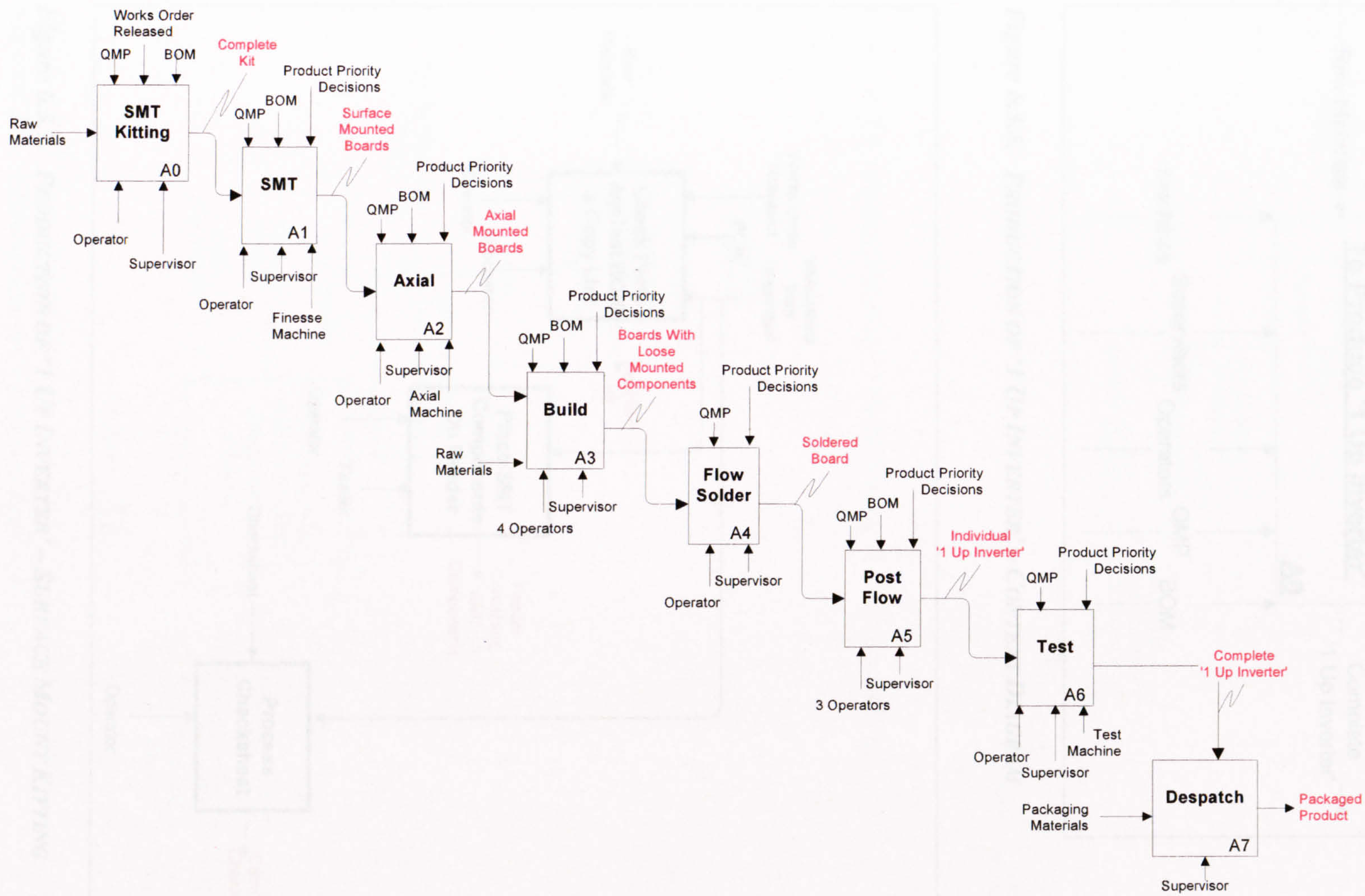

Figure 6.3.5. ***PRODUCTION OF '1 UP INVERTER' – PROCESS OVERVIEW DIAGRAM***

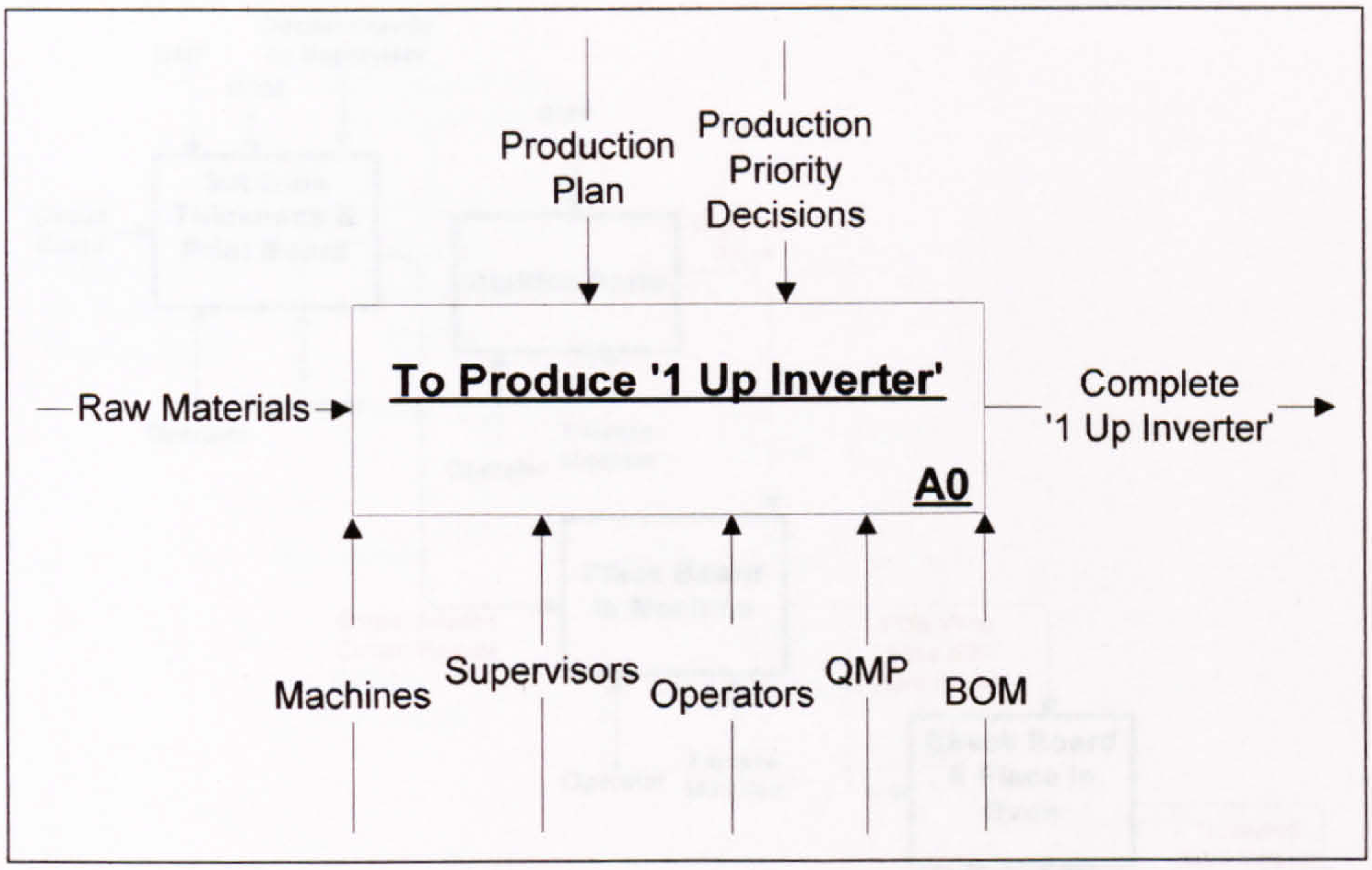

Figure 6.3.6. **PRODUCTION OF '1 UP INVERTER' – CONTEXT DIAGRAM**

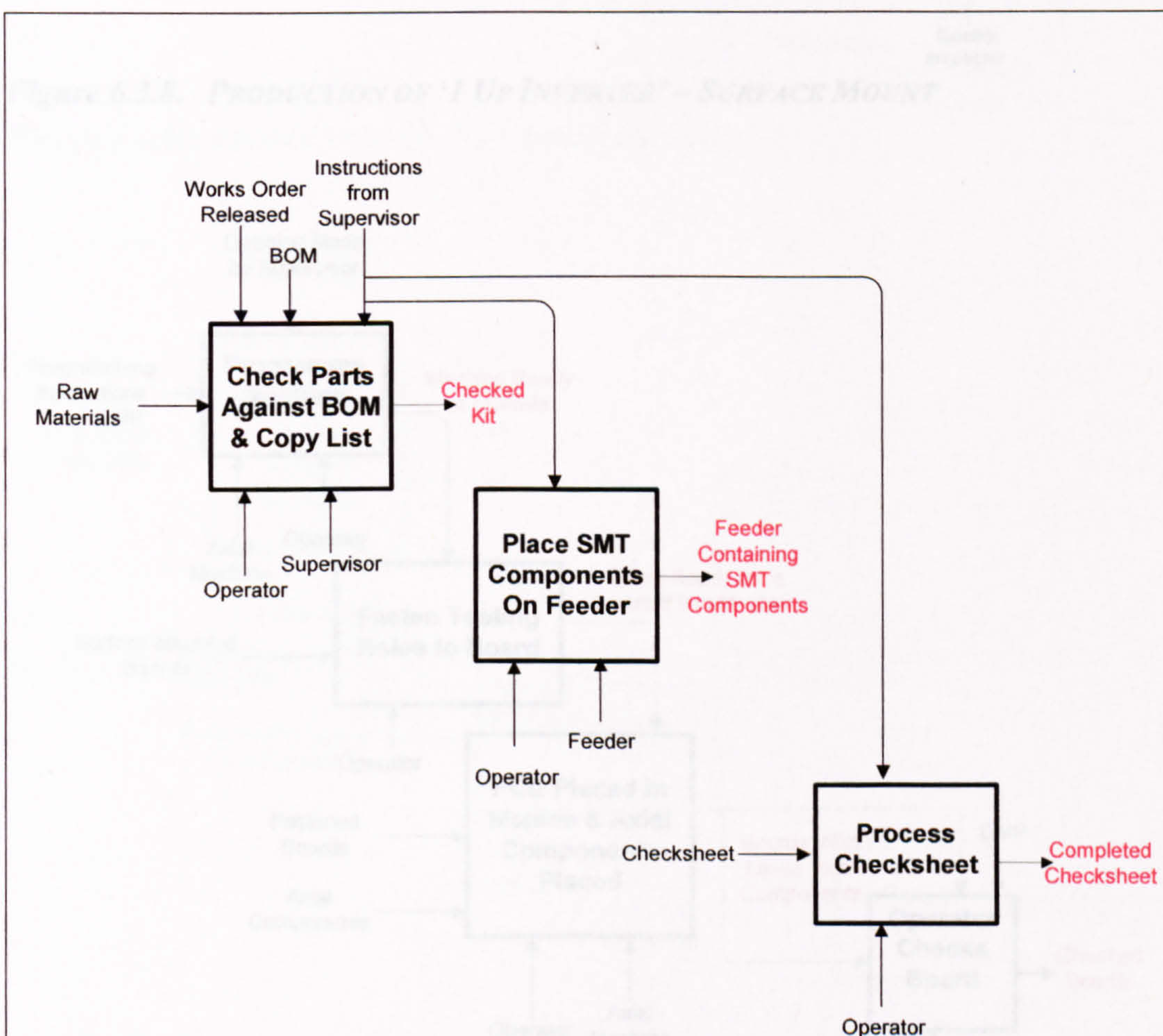

Figure 6.3.7. **PRODUCTION OF '1 UP INVERTER' – SURFACE MOUNT KITTING**

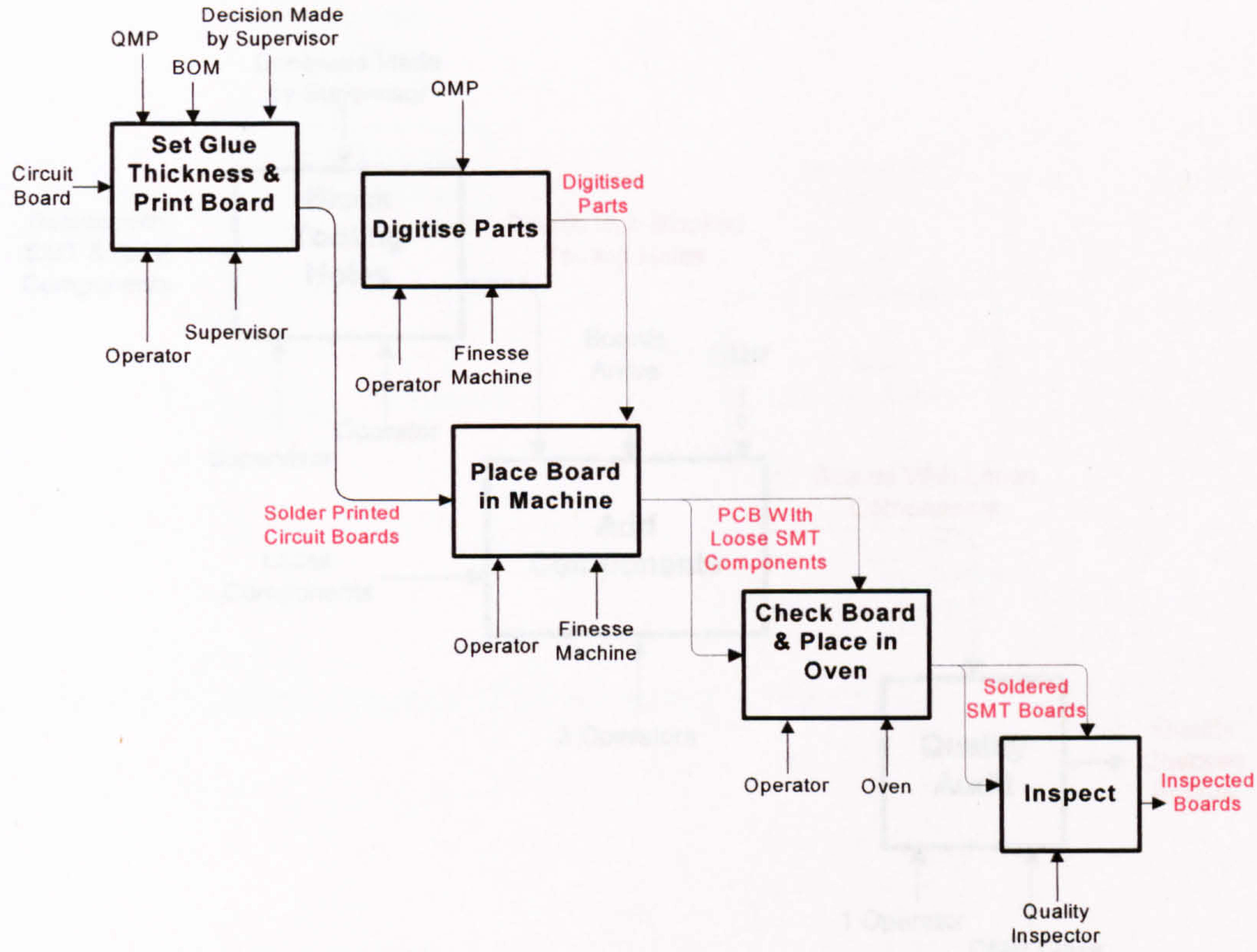

Figure 6.3.8. ***PRODUCTION OF '1 UP INVERTER' – SURFACE MOUNT***

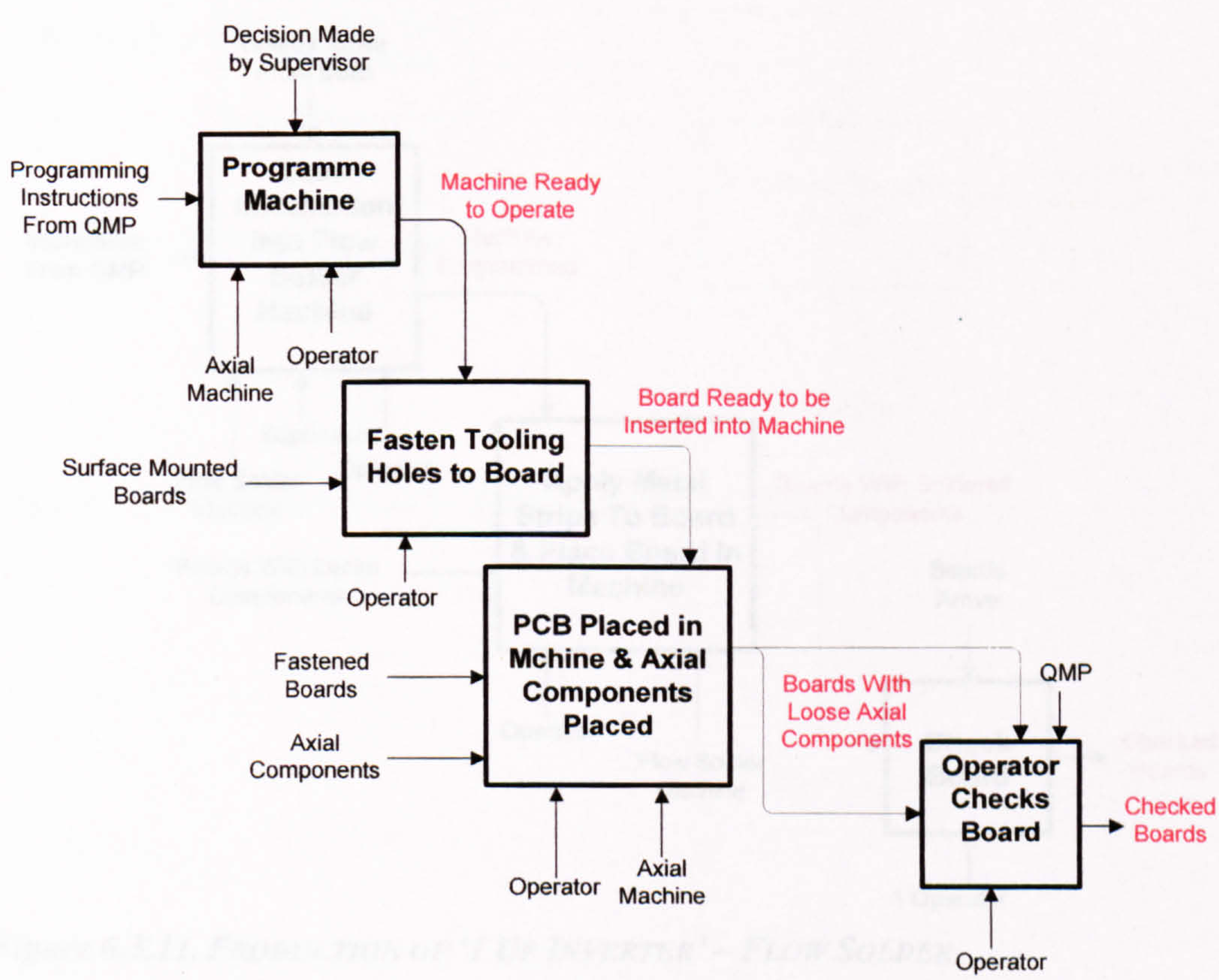

Figure 6.3.9. ***PRODUCTION OF '1 UP INVERTER' – AXIAL***

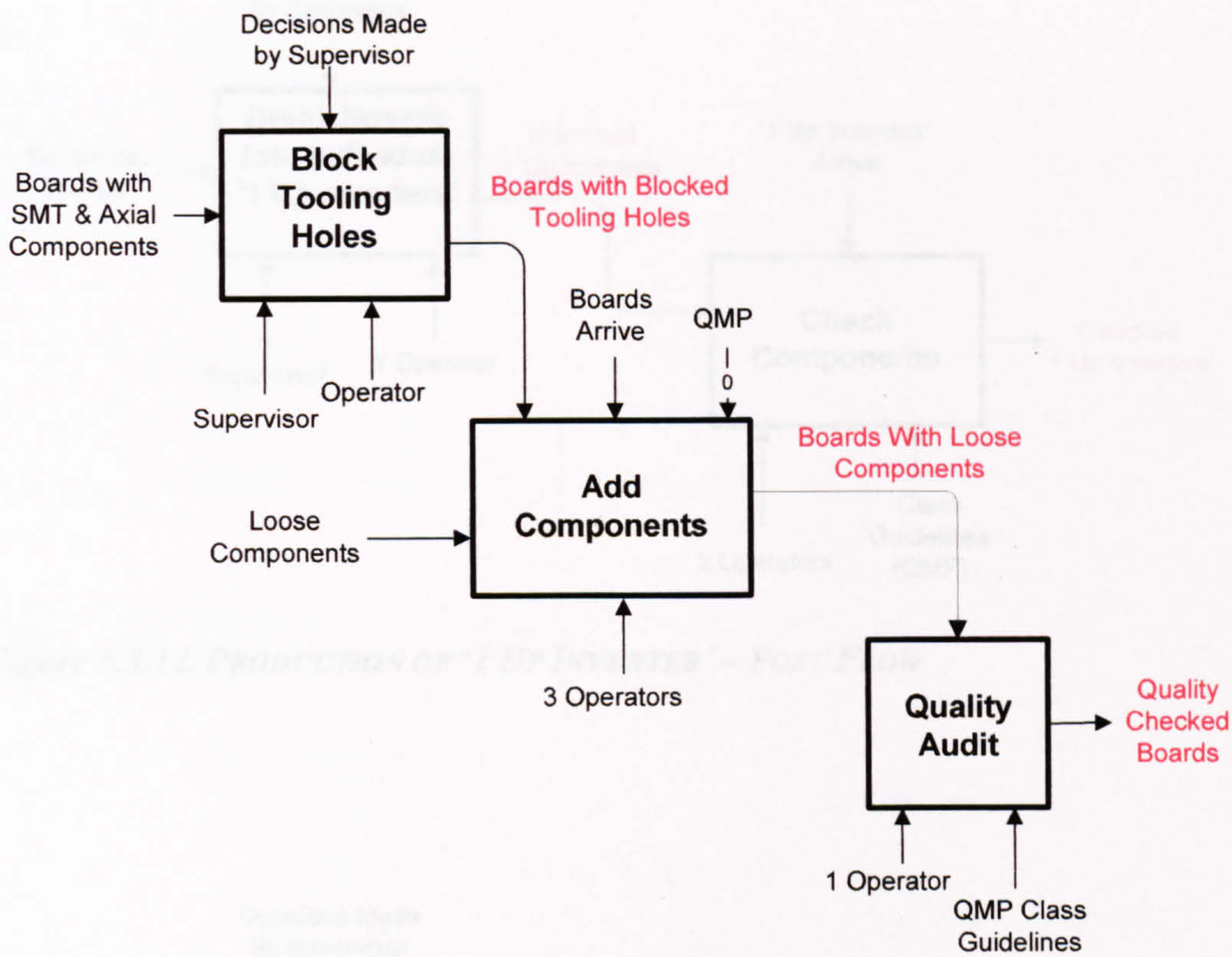

Figure 6.3.10. **PRODUCTION OF '1 UP INVERTER' – BUILD**

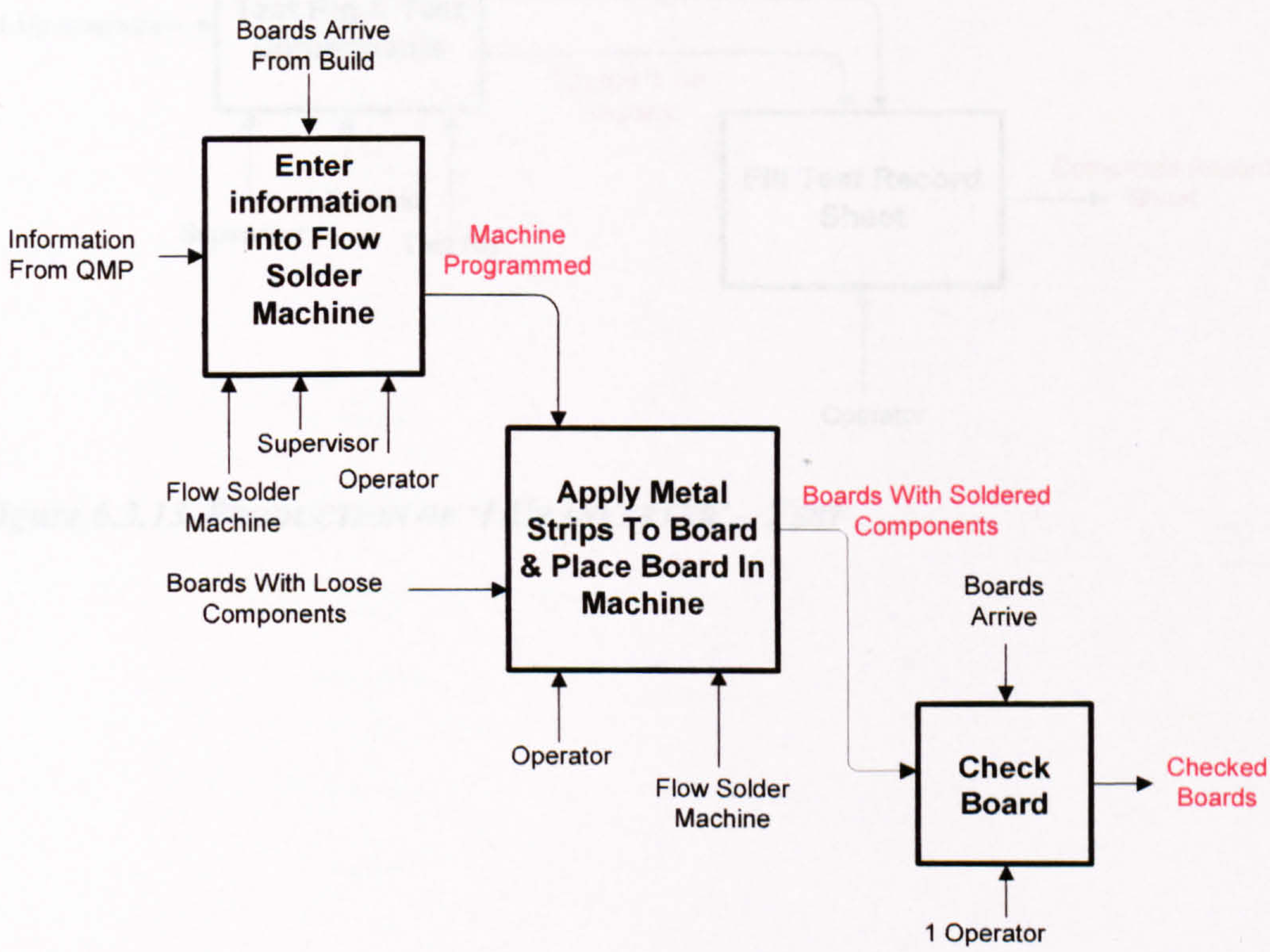

Figure 6.3.11. **PRODUCTION OF '1 UP INVERTER' – FLOW SOLDER**

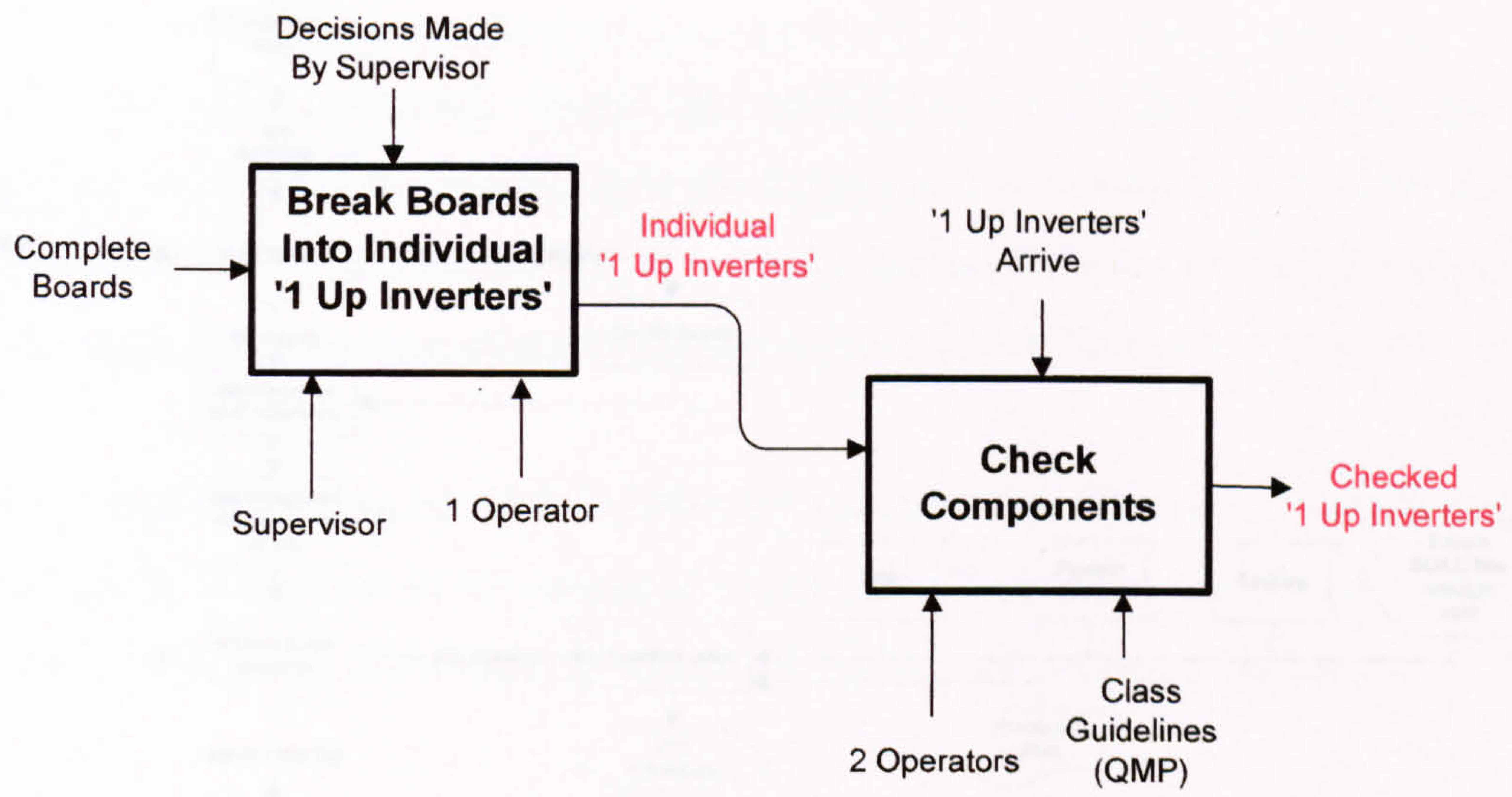

Figure 6.3.12. PRODUCTION OF '1 UP INVERTER' – POST FLOW

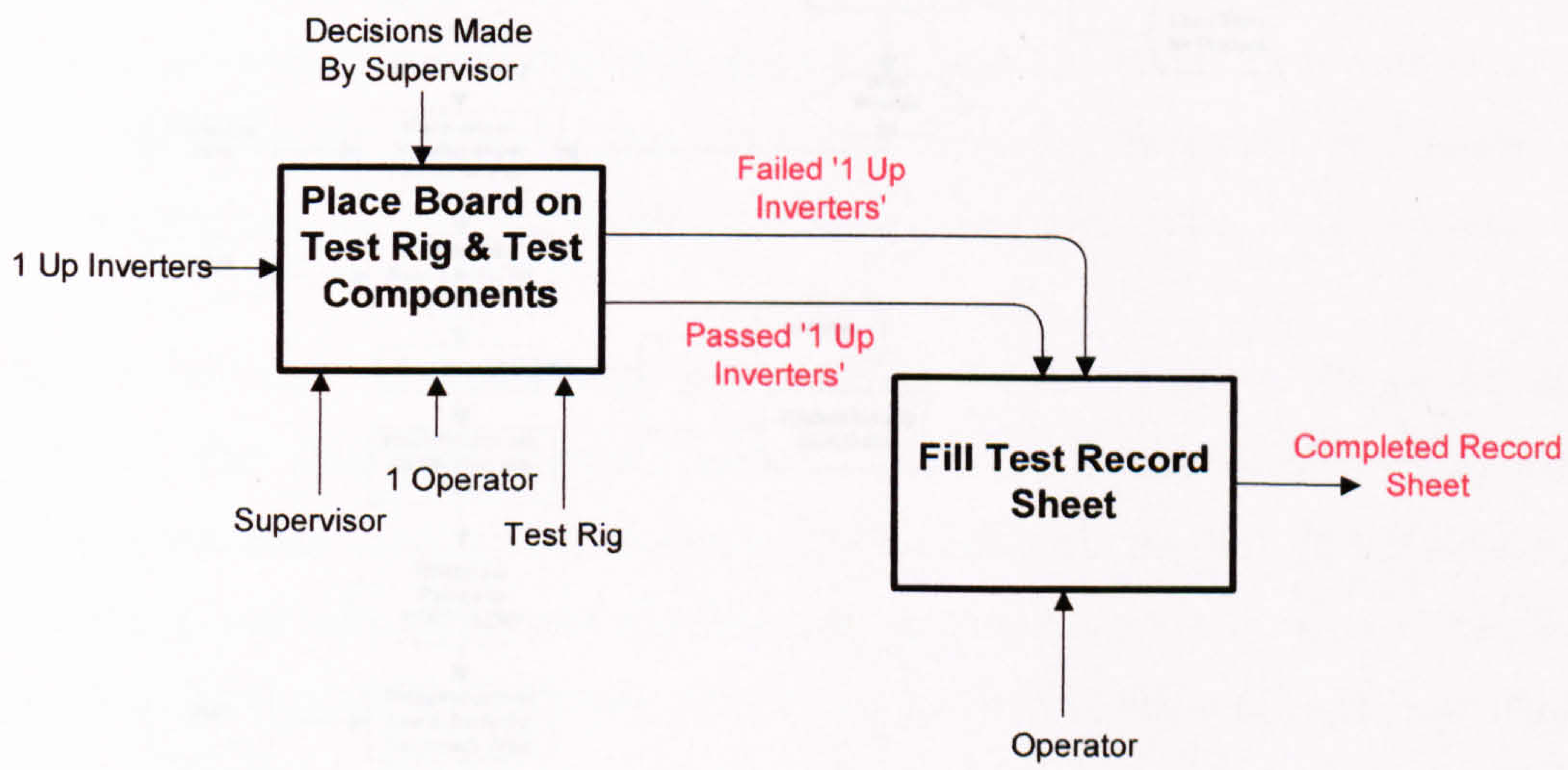

Figure 6.3.13. PRODUCTION OF '1 UP INVERTER' – TEST

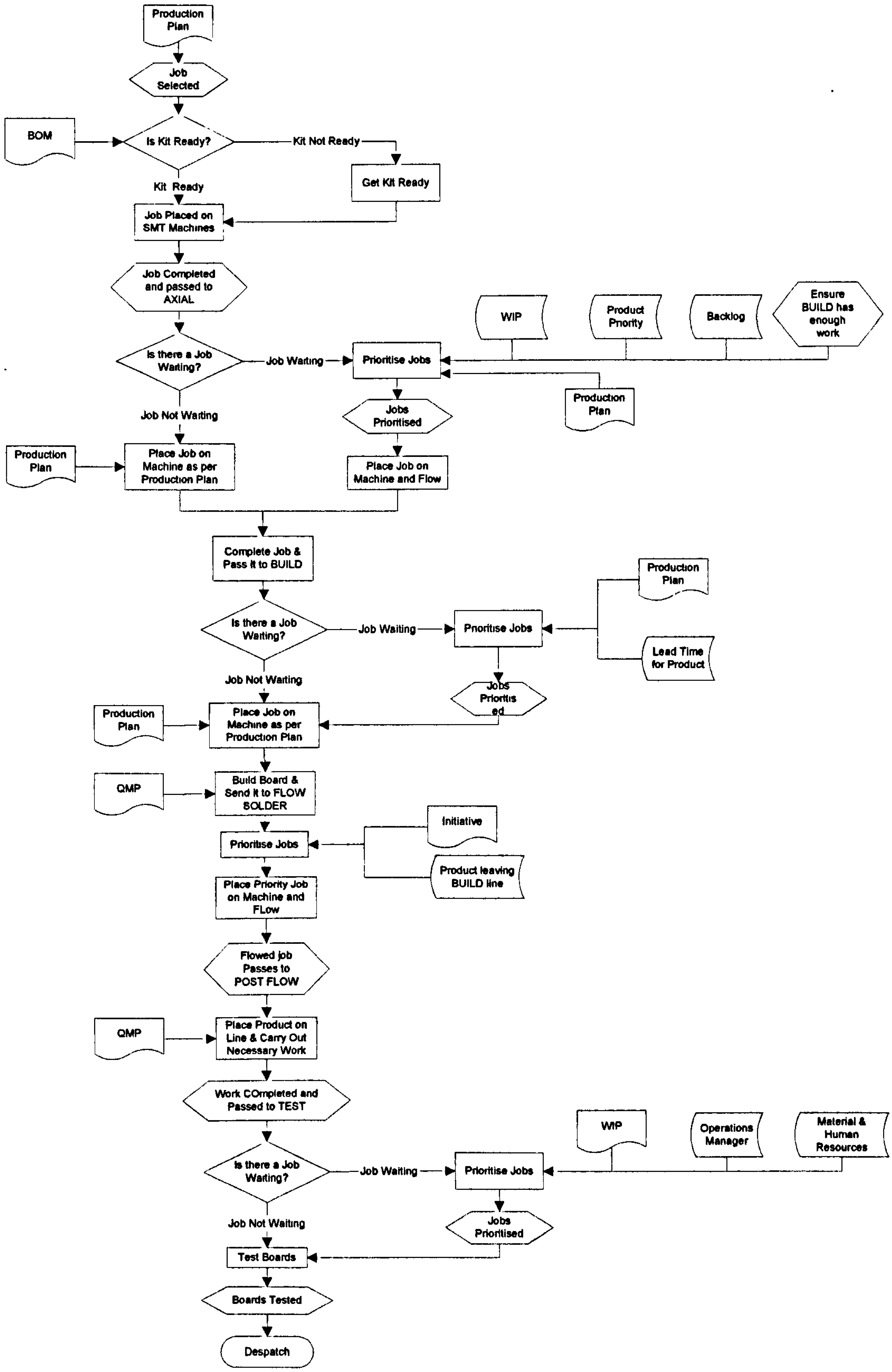

Figure 6.3.14. PRODUCTION OF '1 UP INVERTER' – FLOWCHART OVERVIEW

SIMULATION OF THE SHOP-FLOOR

GRAI and IDEF, although useful for modelling an existing situation, provide relatively little information about how the actions and decisions they describe can be distributed over the people, working in an organisation, in order to form the structure of the re-engineered organisation, and what alternative solutions are available.

A simulated model can be used in order to overcome this. The model is used to test the dynamic behaviour of the proposed organisational structure and obtain a detailed picture of individual workloads, processing times and performance indicators.

The use of a simulation allows data to be collected over time and analysed to identify bottlenecks, adjust system parameters and forecast system performance under a specific workload. This can serve as a basis for comparing alternative organisational structures and choosing the optimal one for a specific situation.

Holding brainstorming sessions with employees who are involved in various areas within the company, using the simulation as a basis for discussion, will allow the development of a deeper understanding of the processes carried out in the business.

The software used to simulate the processes on the shop floor at Chase AT was SIMUL8. The simulation software allows companies to assess changes to their business processes using a PC. It is a powerful tool that lets the user virtually manage staff, implement new equipment and fine-tune customer support for overall business process improvement. The software allows companies to simulate complex operations that are requiring cost reduction and cycle time reduction to improve the quality of products and services delivered to the customer, without disruption to production. It allows the user to validate and justify workflow management operations in real-time.

The simulation of the shop floor at Chase AT is built using the IDEF and business process model as a basis. The format of the information gathered has to be altered to make it suitable for use in the simulation. Data concerning individual workloads and processing times is also required.

SIMUL8 is a Windows based application and so is fairly straightforward to use. Icons representing each process are placed on the screen and data, relating to each process, are entered into the system. The required data includes:

- number of operators;
- time in workstation;
- input;
- output;
- batch size.

The simulation created for this case study initially modelled one line within the factory (Figure 6.3.15). The line produces the '1 Up Inverter'; the processes through which the product passes have been described earlier in this report. Although this is a basic simulation, it illustrated the benefits of using such a tool. The data which was the basis for the simulation, was accurate and precise, therefore the simulation was a realistic representation of the situation along the production line.

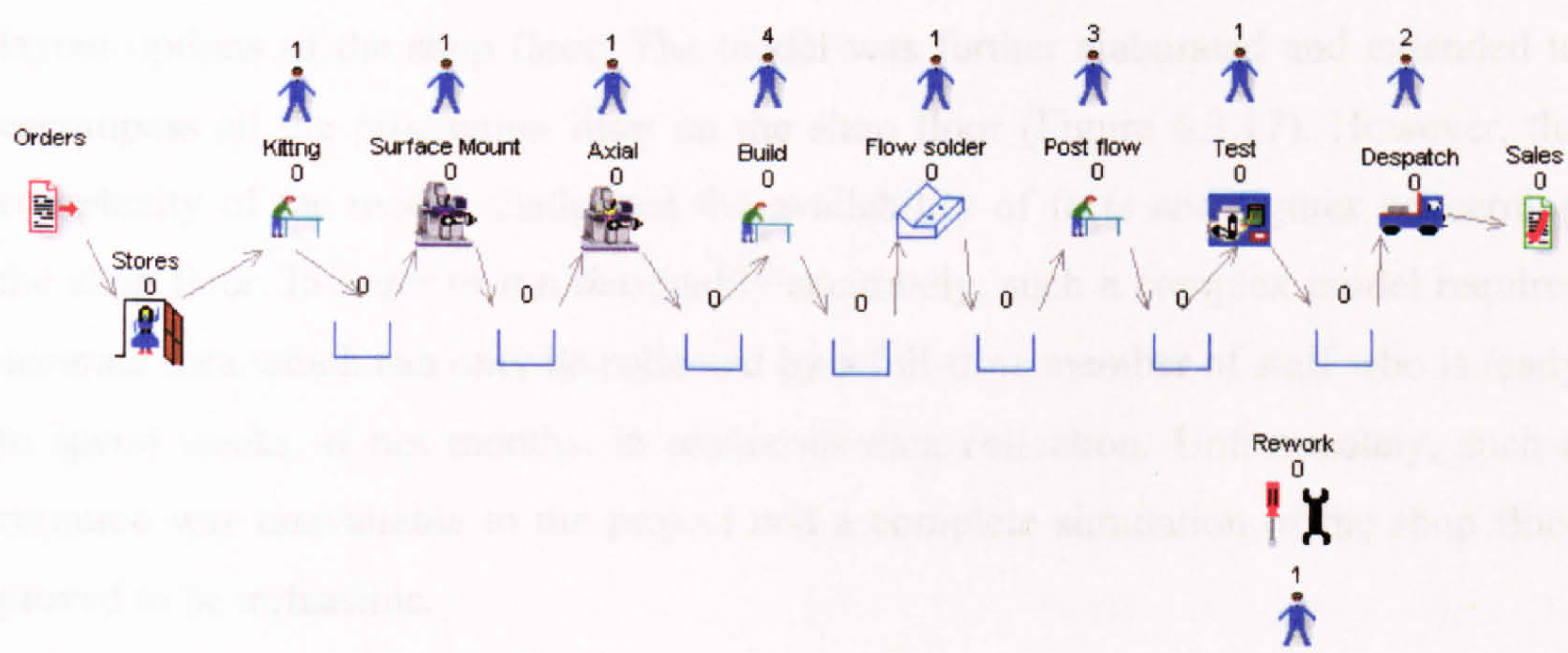

Figure 6.3.15. SIMULATION OF THE '1 UP INVERTER' PRODUCTION LINE

However, in order to enhance the simulation and to further demonstrate its value, a second line was added (Figure 6.3.16). This line contains arbitrary figures but it nevertheless demonstrates the effectiveness of the simulation. This second simulation model is a demonstration of how simulation software can be used to plan the introduction of a new production line on the shop floor and to foresee the result that such an introduction would have on the overall production process. It also helps plan the sequencing of operations and allocation of available resources.

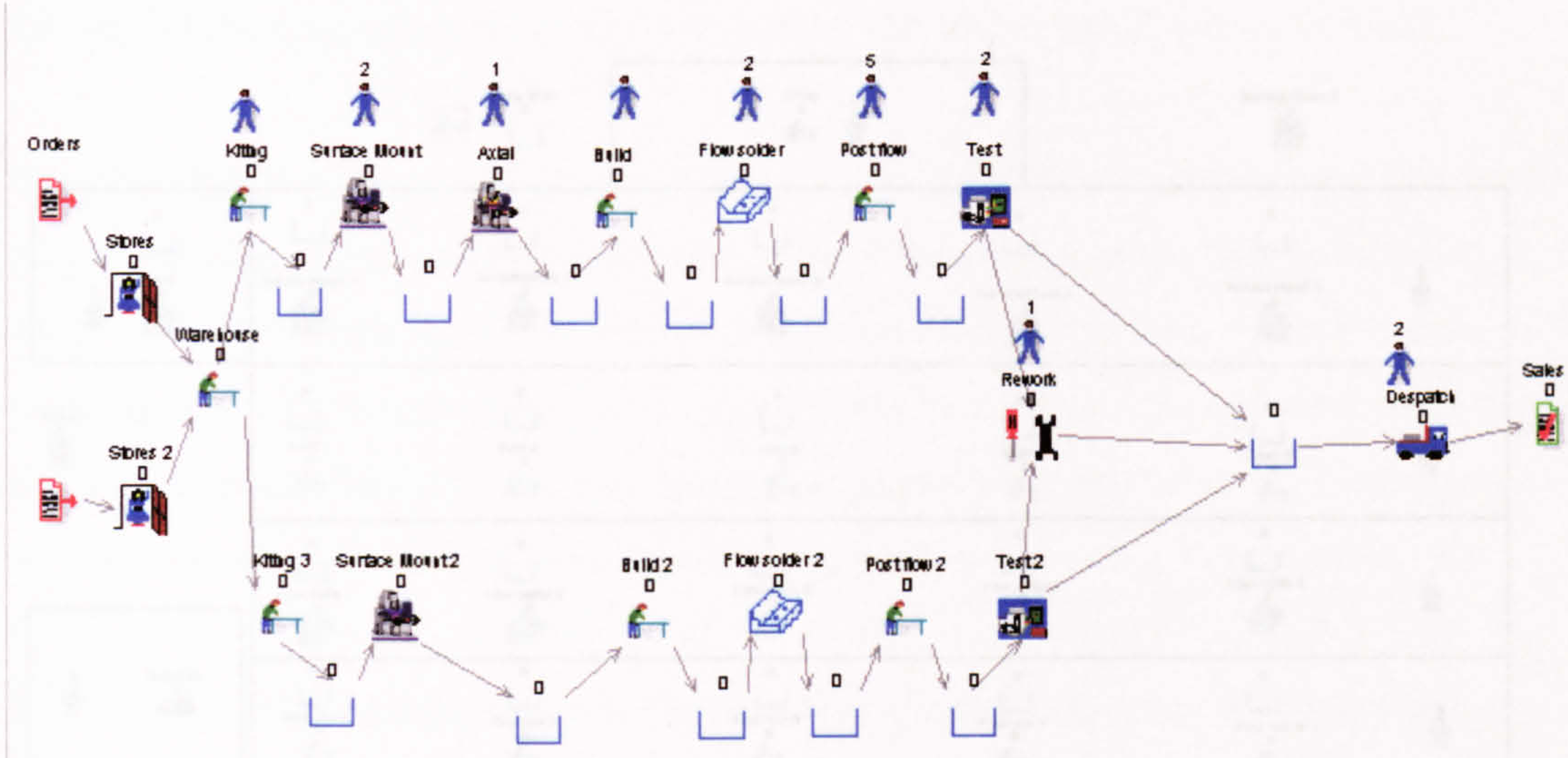

Figure 6.3.16. SIMULATION OF 2 PRODUCTION LINES

Along with simulating the process flow, SIMUL8 can be used to also test out physical layout options of the shop floor. The model was further elaborated and extended to encompass all the production lines on the shop floor (Figure 6.3.17). However, the complexity of the model challenged the availability of facts and figures concerning the shop floor. In order to run reasonably accurately, such a complex model requires accurate data which can only be collected by a full-time member of staff who is ready to spend weeks, if not months, in assiduous data collection. Unfortunately, such a resource was unavailable to the project and a complete simulation of the shop floor proved to be unfeasible.

Next to parameter analysis, SIMUL8 can be used to obtain information about the variable characteristics of the system. These include things such as workload patterns for different workers and the maximum and average amount of time people have to wait before work arrives. On the basis of this information, conclusions can be drawn about the utilisation of resources and about the effectiveness and efficiency of procedures.

The feasibility of any ideas put forward to enhance the system can be tested using the simulation model. In addition to this, forecasts about their effectiveness can be made.

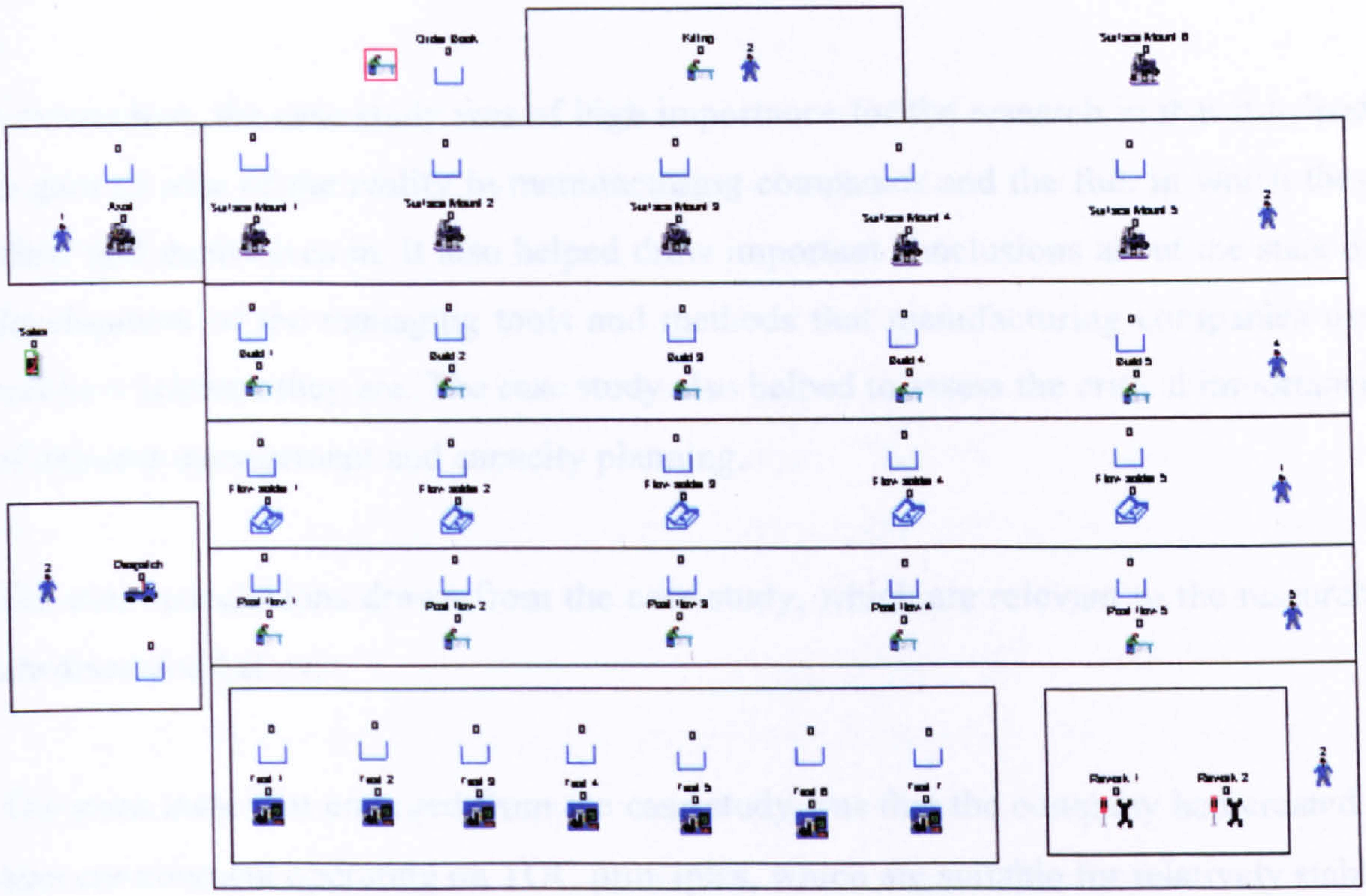

Figure 6.3.17. SHOP-FLOOR LAYOUT SIMULATION

6.3.4 SUMMARY AND CONCLUSIONS

During the period of the case study, Chase AT changed considerably due to a dramatic fall in demand in the electronics industry. Having removed bottlenecks by implementing buffers the constraint on the company is now its market share. Three sets of redundancies occurred during a period of three months. Issues that were high on the agenda at the start of the project no longer applied at the end of the project. The company was now concentrating on cutting costs as opposed to managing profit.

Because of the change in the marketplace, modelling the processes and shop-floor decision-making had been an erratic process, in that the research team was gathering information at one point while also trying to verify the already gathered information only to find out that it no longer applied to the present situation and needed to be gathered anew. In order to come up with a sensible set of findings and simulation models, it proved necessary to focus on a frozen time-frame and avoid updating over and over again the initially collected information. Therefore, the recommendations which would otherwise be given to the Chase AT management team were no longer relevant at the time when the project came to an end and conclusions were drawn.

Nevertheless, the case study was of high importance for the research in that it helped to gain an idea of the reality in manufacturing companies and the flux in which they often find themselves in. It also helped draw important conclusions about the state of development of the managing tools and methods that manufacturing companies use and how relevant they are. The case study also helped to assess the critical importance of demand management and capacity planning.

The main conclusions drawn from the case study, which are relevant to the research, are discussed below.

The main issue that emerged from the case study was that the company had created a lean environment operating on TOC principles, which are suitable for relatively stable high volumes of work and they did not have demand management or capacity planning functions to assist them as demand changed. The TOC was implemented as a part of the development strategy of the company without careful consideration of the dynamics and characteristics of the marketplace. The company missed opportunities for creating a flexible environment, suitable for low-volume product manufacturing and appropriate for the highly volatile demand in the specific marketplace. The assistance of and Improved SCM tool in strategic decision-making would be invaluable to assess the factors that need to be considered in making strategic decisions of that calibre.

Being a typical example of how a medium-sized establishment is run without advanced supply chain management tools, the case study company provided excellent grounds for observing the implications of the lack of such advanced tools and the undesirable consequences for the manufacturing process. The case study helped the researcher conclude that, although the lack of supply chain tools and methods employed by the company's management was probably not the main reason for the irrelevant shop floor organisation and manufacturing control, it had an important part to play and could be looked into as a start to trying to solve the issues the company was facing.

It was clear from the way the business was run that the supply chain management strategy the company followed was inconsistent with the market position of the company and the general processes in the market itself. The manufacturing process was managed primarily using rules of thumb and following innovative ideas (such as the TOC) rather than a well thought out strategic model.

Supply chain processes within the company were not considered as an entity and an inseparable part of the entire supply chain, from which the company was a part. Instead, manufacturing was considered to be one separate area, suppliers were treated as another area with different problems which needed a different approach to solving them; problems with finding new customers and keeping the current ones were a concern of the sales and marketing department whose operation was independent from the other departments. Integrating the supply chain at Chase AT was obviously one of the most urgent issues to be solved. An important conclusion can be drawn from this: that close integration between the different functional areas in the supply chain and operating these with a consistent strategic plan for the development of the entire supply chain are crucial for the successful operation of a business. It is also important to use SCM tools and techniques which cater for this need.

Chase AT, like all manufacturing companies, needs to plan the manufacturing process in accordance with the current market situation and be able to react promptly to increases, as well as sharp decreases in demand; for this purpose, a SCM piece of software would be of great value in that its demand and capacity planning functionality would enable the user to synchronise output with demand and plan for the possible need to increase or decrease capacity.

Besides the long-term planning of the shop floor operations and assisting in making decisions about the optimum shop-floor layout, a SCM tool would also assist in day-to-day shop-floor scheduling by presenting the relevant up-to-date data in the context of the existing long-term strategic development plans of the company. Scheduling needs to be carried out in a logical manner, rules of prioritisation and standardised management practices should be applied not only during the planning stage but also on an ad-hoc basis, e.g. when an urgent rescheduling of production proves necessary. It is the SCM tool that will have the task to enable the structured and planned manner in which that will be carried out in order not to forfeit the overall direction in which the company as a whole is going. Knowledge of the processes, work studies and monitoring are necessary to make sure that management, planning and scheduling decisions are based on real, up-to-date information.

A simulation tool, used in conjunction with the SCM system and drawing accurate and up-to-date information from it, will clearly benefit the operations. However, its usage should be combined with improved communications throughout the company. That is why Chase AT would be advised to look into the somewhat deficient communication between the offices and the shop-floor. It needs to be a two-way process with management defining the processes in accordance with the strategic goals of the business but with the shop-floor providing feedback to the management system in order to keep the strategic orientation relevant and up-to-date and modify it if necessary to accommodate contingencies.

Chase AT would be advised to invest in developing a better visibility throughout the supply chain. A particularly challenging problem was identified in the communications with its customers, due to which no reliable forecasting data was available for planning. Whereas a SCM system would not by itself solve the problem, it would highlight the urgency of the situation and would motivate the management to take prompt action.

One of the most important conclusions from case study 2 is that data availability and information sharing, as well as supply chain integration in order to enhance those, are critical for the successful management of the supply chain. Integrating the data about demand, coming from the customers, with shop floor capacity utilisation and with the data from the other operations within the supply chain into a single supply chain management model, supported by modelling and simulation tools, would have helped to address the majority of the problems that Chase AT was facing at the time when the case study was carried out.

6.4 CASE STUDY 3: SUPPLY CHAIN MAPPING AT ADAMS

6.4.1 INTRODUCTION

The third case study that was undertaken during the research process maps the supply chain of a large manufacturing company in the confectionary business. The company has a well established international supply chain with suppliers of raw materials, as well as customers all over the world. As such, the company offered a valuable opportunity to explore the issues of managing a huge supply chain and to find out what tools and techniques were used at that particular moment in time. During the progress of the research, it was found that the company, surprisingly for its size and excellent financial position, as well as its advanced management thinking and operations, was utilising no advanced software tools for managing its supply chain. Consequently, the researcher focused on addressing the need to employ such a tool and helped to designing a bespoke analytical tool to provide the required visibility of the supply chain. Due to the time limitation, the researcher focused on addressing the most impending need at the company – that is, to provider improved visibility into the supply chain structure. The latter resulted from the finding that, although detailed data about the various supply chain nodes was available to management, it was rarely useful due to its amount and the lack of systematic way to present it.

The purpose of this case study was to look beyond the existing SCM software functionality and to suggest a tool for analysing the strengths, weaknesses and opportunities for improvement of a manufacturing supply chain by providing enhanced visibility into the various parameters of the supply chain. The specification of the tool will justify the data requirements and will demonstrate how data sharing and trust within the supply chain can enhance visibility throughout the supply chain and thus help optimise the processes of the entire supply chain, bringing benefit to all.

The "diagrametric" supply chain map is a novel way of viewing a supply chain. All the parameters of the supply chain which define its capacity, production volume and cost, suppliers (along with the raw materials volume and cost), manufacturing sites and markets are included in a single diagram which incorporates representations of activity levels within the supply chain. The synoptic, visual way in which the supply chain is represented offers an excellent decision support to the supply chain manager who can use it for decision making.

6.4.2 THE CASE STUDY COMPANY

Pfizer Inc. is a global pharmaceutical and health care company, currently ranked at number 49 in the Fortune 500 (Fortune, 2002), with an annual sales turnover of $32 billion in 2001. The Adams Division of Pfizer provided the case study. It is the company's confectionery business, which also operates globally. Turnover in 2001 was $2 billion (Pfizer Inc, 2002). The company is the eighth largest confectionery company in the world, by turnover, behind such global companies as Nestle, Mars, Hershey, Cadbury and Kraft (Davies, 2001). Adams is market leader in a number of different countries in the product areas in which it competes.

Adams manufactures and markets a wide range of medicated and non-medicated confectionery. The medicated brands, which use active ingredients such as menthol, eucalyptus and ascorbic acid, include Halls, the world's leading boiled candy brand, Soothers, Clorets and Vita-C. Non-medicated brands include chewing gums such as Dentyne and Trident, bubble gums such as Bubbaloo and Bubblicious and mints such as Certs.

The company provides a very good example of a global supply chain. It operates 21 production plants and competes in more than 60 countries around the world. Each plant will, typically, produce for a number of different countries. Each country will, typically, source from a number of different plants. In addition, there are a number of third-party manufacturers contracted to produce various products to supplement the global supply network. Plants will sell their products on an intra-company basis to the Adams affiliate in the countries to which they ship goods. The Adams affiliate will then sell the goods to the wholesalers and retailers and, in some cases, to distributors which cover countries in which Adams does not have an affiliate office. In some cases plants will also sell goods directly to a distributor. Plants are usually focussed on a small range of products and consequently, goods are often shipped over large distances, sometimes between continents, to satisfy market demand. Consequently, with such a complex network, the supply chain has an important role to play in ensuring that the company operates efficiently and that the requirements of trade customers and the ultimate consumer, are met.

6.4.3 TOOL DESCRIPTION

The tool developed in the case study took the form of a diagrametric supply chain map. The aim of the diagrametric supply chain map is to enable the decision-maker to easily spot specific problem areas within the supply chain which has been mapped. The need for such a tool became apparent when, during the initial introduction to the company, the researcher was presented with voluminous data about the various operations, manufacturing sites, raw materials, suppliers, customers and sales amounts. The researcher found it challenging to go through the data and make sense of how it provides a picture of the Adams supply chain. The next logical step in the case study was to find out whether the management of the company had a tool or method of modifying this data and turning it into information useful for decision making. The findings from the enquiry and ad-hoc interviews were surprising – although high quality data was readily available, it was rarely used in a systematic way. There were sporadic analyses of the available data but systematic data reduction and interpretation was not carried out at the company. There was a recognised need for a tool which puts together all the bits and pieces of data coming from the various operational fields and displays it and reports it in a user-friendly, meaningful way. The diagrametric supply chain map was the tool, designed by the researcher, which was aimed at addressing all these issues of data analysis and utilisation. The current section describes in detail its features and functionality.

The name "diagrametric" supply chain map, was coined with the aim of suggesting the functionality of its key elements. The map is based on a number of diagrams which show activity levels in proportion to each other within the area of the supply chain which has been mapped. The disparate diagrams are "metered" against each other so that, when viewed together, they provide a realistic comparison between the different supply chain functions, making the whole supply chain look coherent.

The diagrametric supply chain map presents the material flow within the supply chain. Wherever possible, the financial value of the transactions is integrated with the main material flow. In that way, the route of the materials can be traced through the supply chain along with the value adding operations.

To make the diagrametric supply chain map more user-friendly, the main types of materials, product groups and consumer markets are colour-coded in easily distinguishable colour schemes. In this way, once the user becomes acquainted with the colours and their corresponding meanings, it is possible to have an "at-a-glance" idea of the material flows throughout the supply chain. The coloured areas in the diagrams are to scale compared with similar components so volumes of an item (for example raw materials, product groups, or market sales) are easy to compare.

The original size of the diagrametric supply chain map is an A0-size poster. It has to be printed on a full-colour plotter which allows printing A0 sized diagrams.

Figure 6.4.1 shows a scaled screenshot of the map. Some of the components and most of the text are hardly visible due to the huge reduction in size in order to fit an A0 sized image onto an A4 sized page. To provide a more clear image of the supply chain map, the author provided an A3-sized screenshot of the map in Appendix 6.1.

The diagrametric map represents the entire supply chain of a company. It has four major sections which are easily distinguishable. These are designated areas on the diagrametric map for each of the following: Suppliers, Manufacturing sites, Distribution and Markets. The entity of the supply chain is enhanced by the usage of the same tools and techniques and tools to represent the same component throughout the whole map. For example, the products are represented with the same colour codes both in the Manufacturing sites section and the Markets section; the geographical areas use the same colour code throughout the map; the largest volumes of raw materials supplied, the largest manufacturing sites and the largest markets are at the top of the map, whereas the smaller ones are below them, ending with the smallest at the bottom.

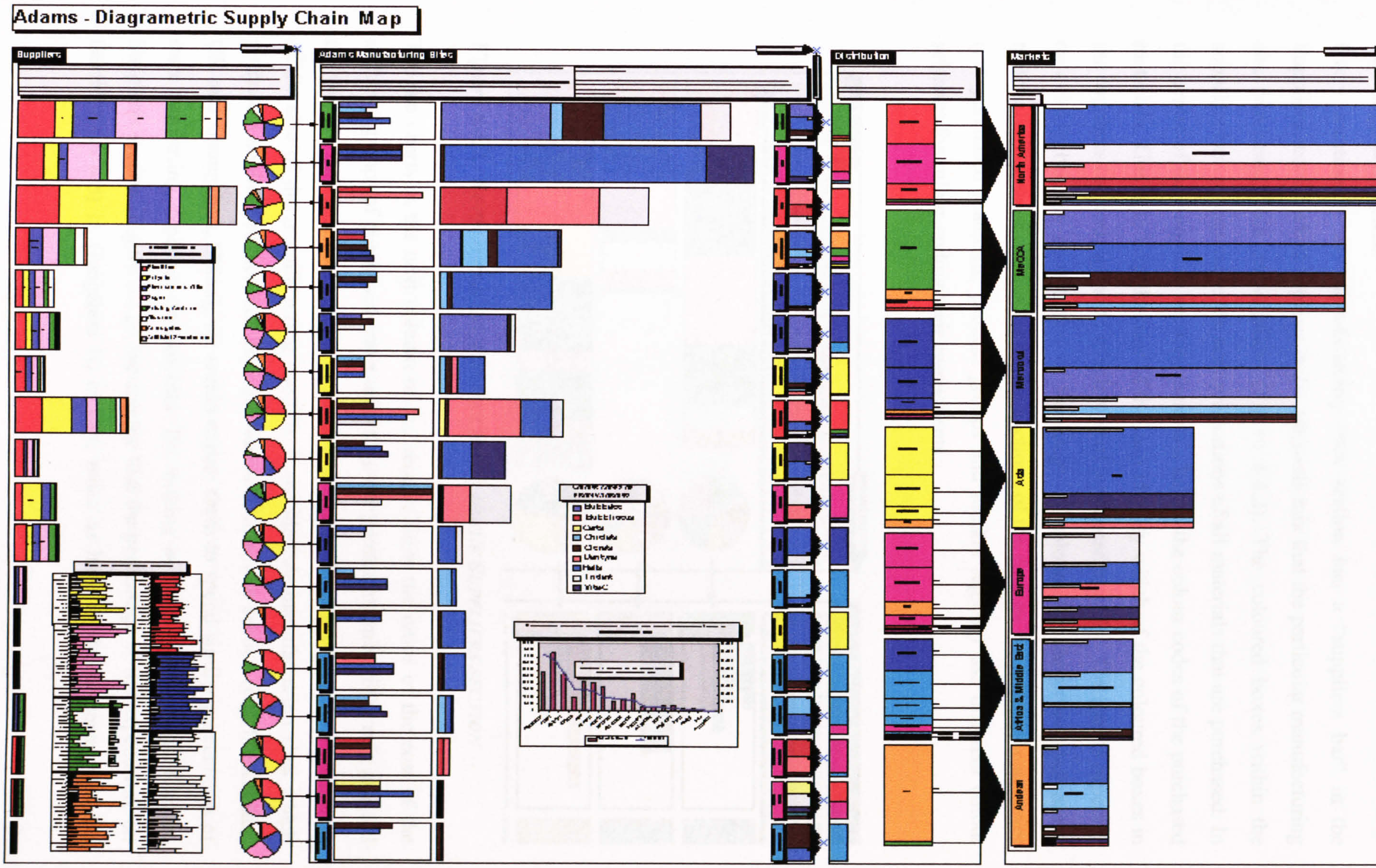

Figure 6.4.1. PHYSICAL LAYOUT OF THE DIAGRAMETRIC SUPPLY CHAIN MAP

The Suppliers section

Every location in the Manufacturing sites section has a "suppliers bar" in the Suppliers section which represents the materials mix that the particular manufacturing site purchases from its suppliers (Figure 6.4.2). The coloured boxes within the suppliers bar correspond to the cost proportions of all materials that are purchased. In the centre of the Suppliers section, there is a key to the colour codes of the purchased materials. This is to help the user of the map identify which of the coloured boxes in the suppliers bar correspond to which type of purchased material. The user is expected to quickly become accustomed to the usage of colours for identifying purchased materials. The same applies for all the sections of the map as the different categories (i.e. purchased materials, product groups and market regions) use different colour schemes for colour-coding their components.

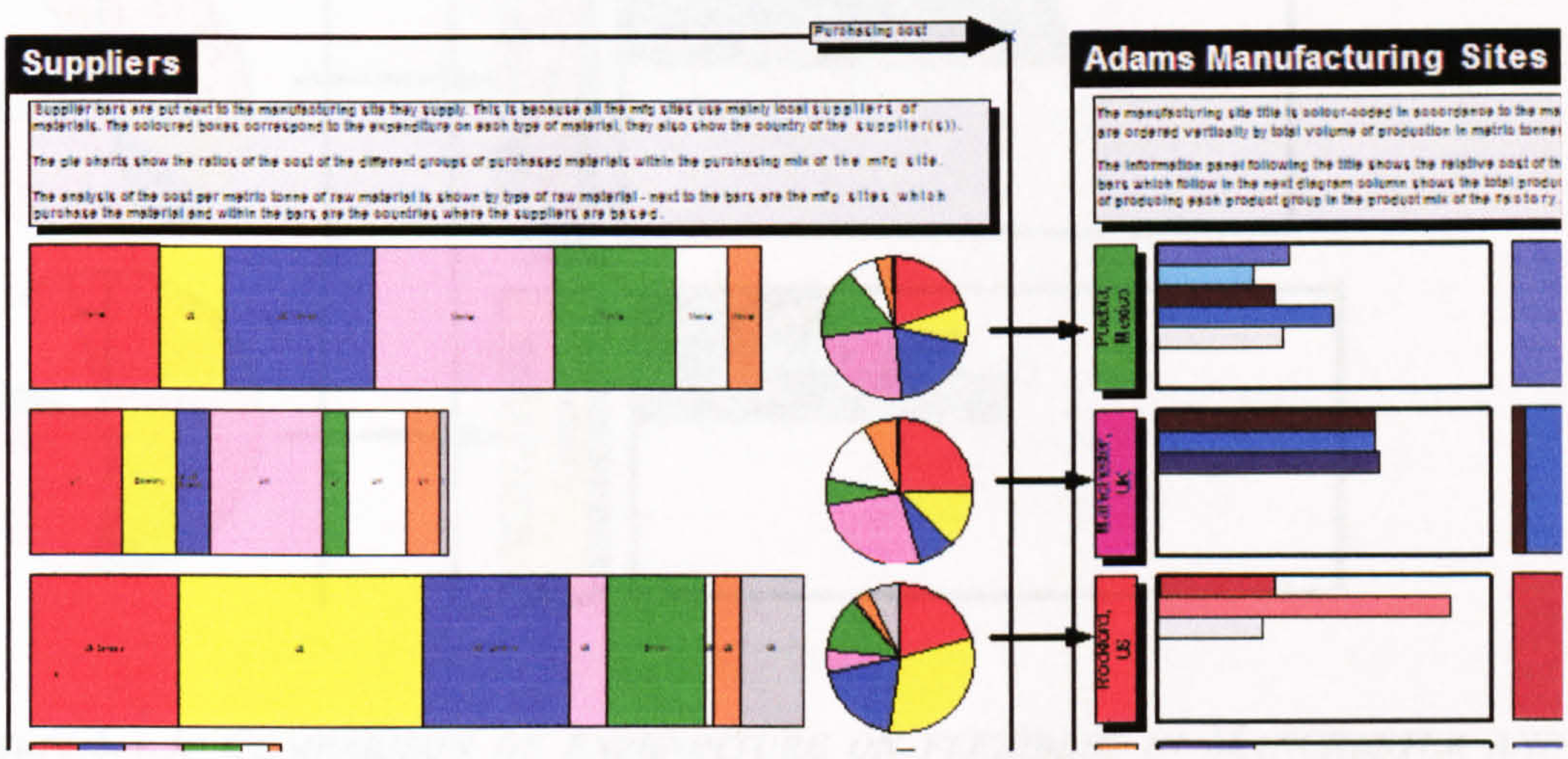

Figure 6.4.2. ***SUPPLIERS BARS AND PIE CHARTS IN THE SUPPLIERS SECTION***

The pie charts in the next column of the section show the ratios of the cost of the different groups of purchased materials within the purchasing mix of the mfg site. All the pies are the same size to make it easier to compare the cost proportions regardless of the size of the manufacturing site (i.e. if we identify manufacturing sites which produce a similar product mix from the Manufacturing site section (e.g. Manchester, UK and Guangzhou, China), we would expect them to spend similar percentages of their purchasing expenses on flexibles. By looking at the pie-chart column in the Suppliers section (Figure 6.4.3), we can see that the percentage of the expenditure on flexibles (in red) in Guagzhou is, in fact, twice as high as the percentage of the expenditure on flexibles in Manchester. This makes it very easy for the supply chain manager to identify possible problems or inefficiencies in the supply chain. If the anomaly does not have a logical explanation, it can be subjected to rectification. One possible explanation of this anomaly could be that the price of flexibles might be very sensitive to the volume purchased and thus China is paying a much higher price due to the fact that the volume purchased is much lower than the volume purchased by the UK site. If this is not the case and the supply chain manager is not aware of any other reason, he may find it necessary to study the anomaly and find an efficient rectification. It might be economically justified to try to find a cheaper supplier locally, or even to purchase from the UK supplier and ship the materials to the site in China.

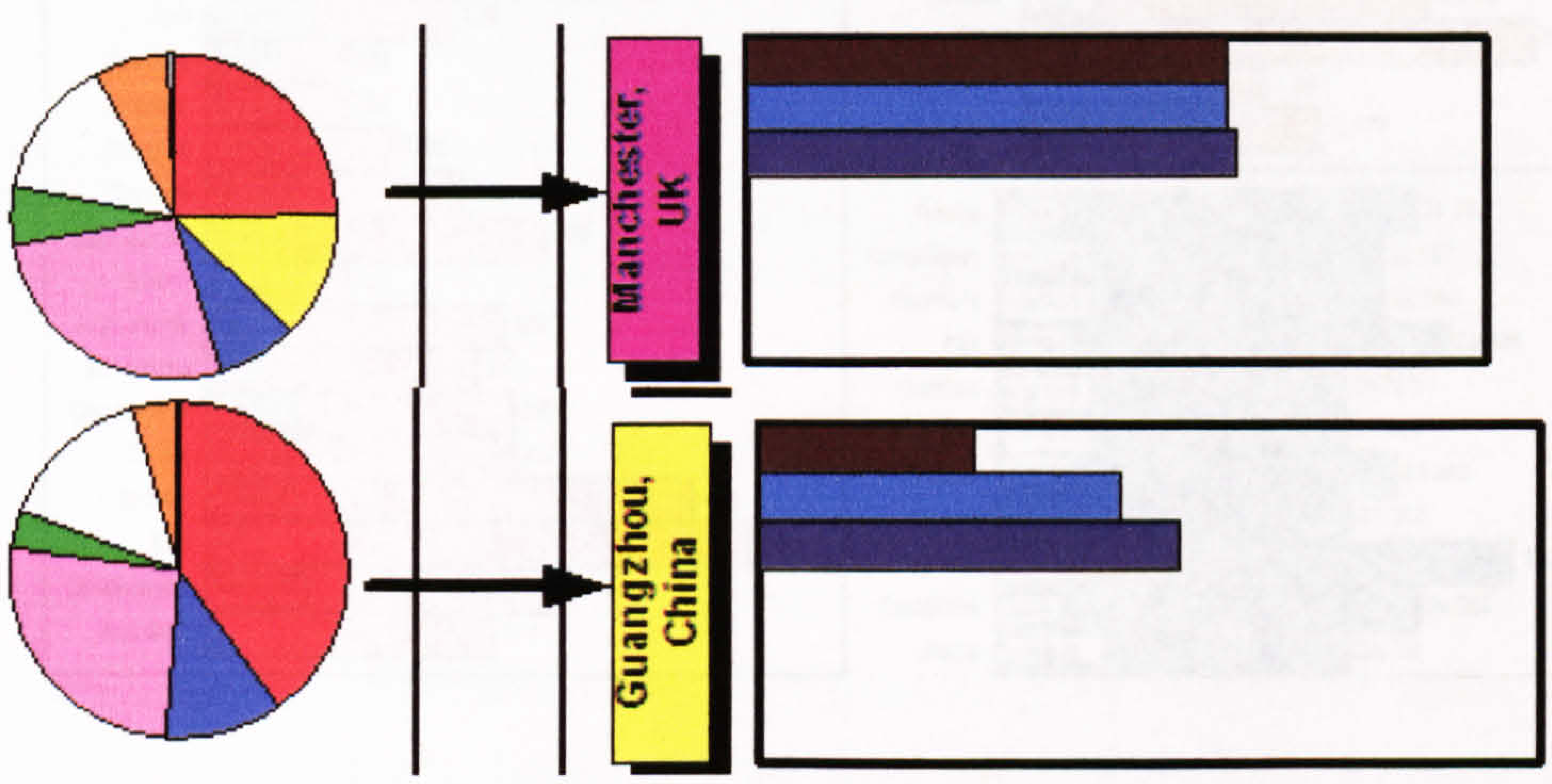

Figure 6.4.3. ***COMPARISON OF EXPENDITURE ON FLEXIBLES IN MANCHESTER AND GUANGZHOU***

The Suppliers section of the diagrametric supply chain map has one more component - analysis of the cost per metric tonne of purchased material (Figure 6.4.4). The analysis is shown by type of raw material and the horizontal lines of the bar charts show the price per tonne at which each manufacturing site purchases its materials. The manufacturing sites are ordered in the same sequence as they are in the Manufacturing sites section (i.e. highest volume of production is at the top, lowest volume is at the bottom) in order to make it simple to identify whether the price of the particular material is sensitive to the purchasing power of the manufacturing site (assuming that the higher the volume of production the higher the purchasing power of a manufacturing site). From the map, it seems that an example for such a commodity is glucose.

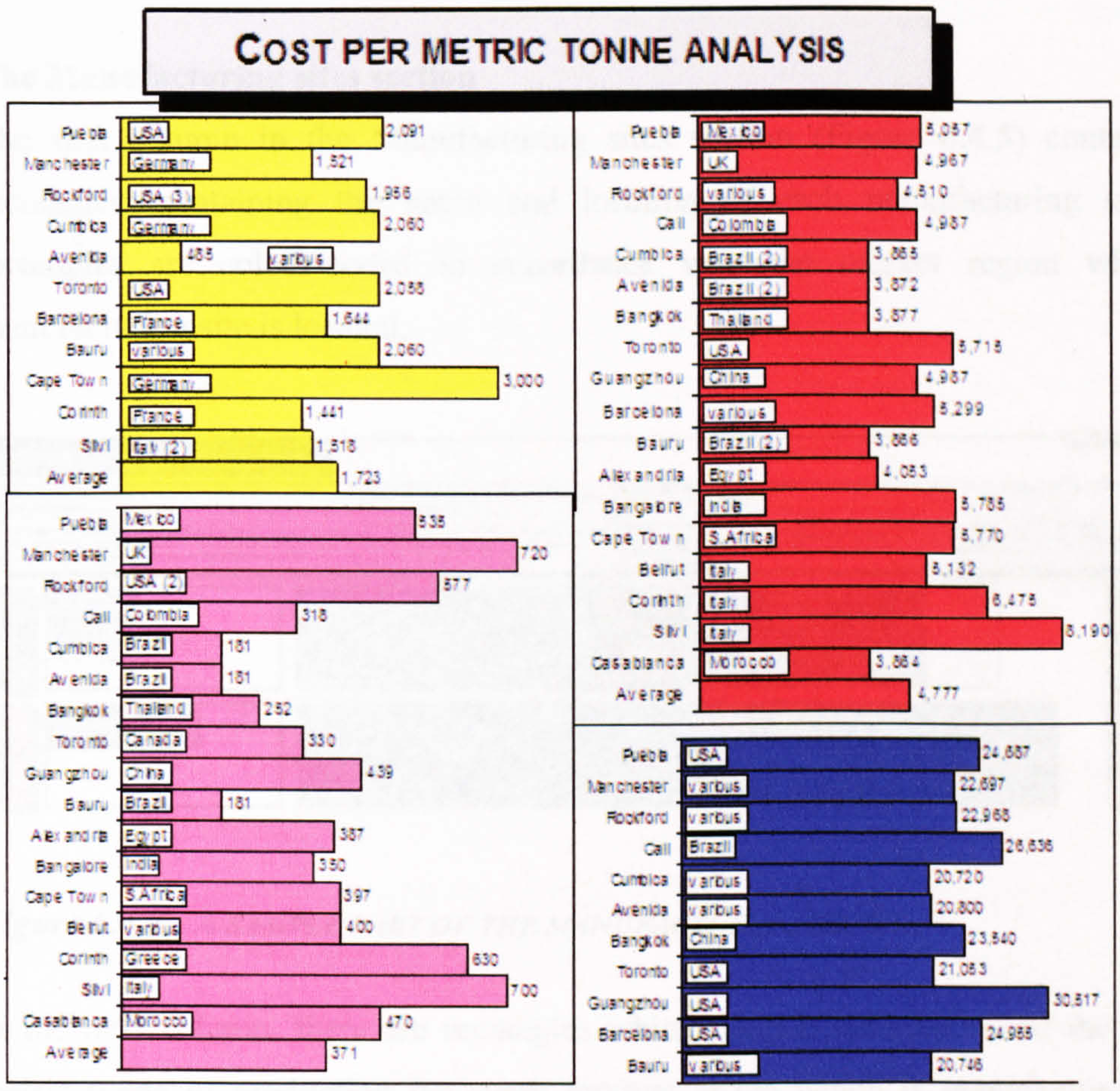

Figure 6.4.4. ***ANALYSIS OF THE COST PER METRIC TONNE OF PURCHASED MATERIAL***

Next to the lines of the bar-chart corresponding to each manufacturing site are the names of the countries from which the particular manufacturing site purchases the material. If there are a large number of suppliers based in different countries, the supplier name field says "various". However, if there are a number of different suppliers based in the same country, the field indicates the name of the country and the number of suppliers in brackets. The reason for showing the geographical position of the suppliers is to make it easier to analyse probable distance inefficiency between the supplier and the manufacturing site. Also, if there are two manufacturing sites which source from the same country but pay significantly differing prices, it might be justified to combine the purchasing order and place it with the cheaper supplier, thus achieving an economy of scale and not incurring higher transportation costs than the present situation.

The Manufacturing sites section

The first column in the Manufacturing sites section (Figure 6.4.5) contains title rectangles, containing the name and location of each manufacturing site. The rectangles are colour-coded in accordance with the market region where the manufacturing site is located.

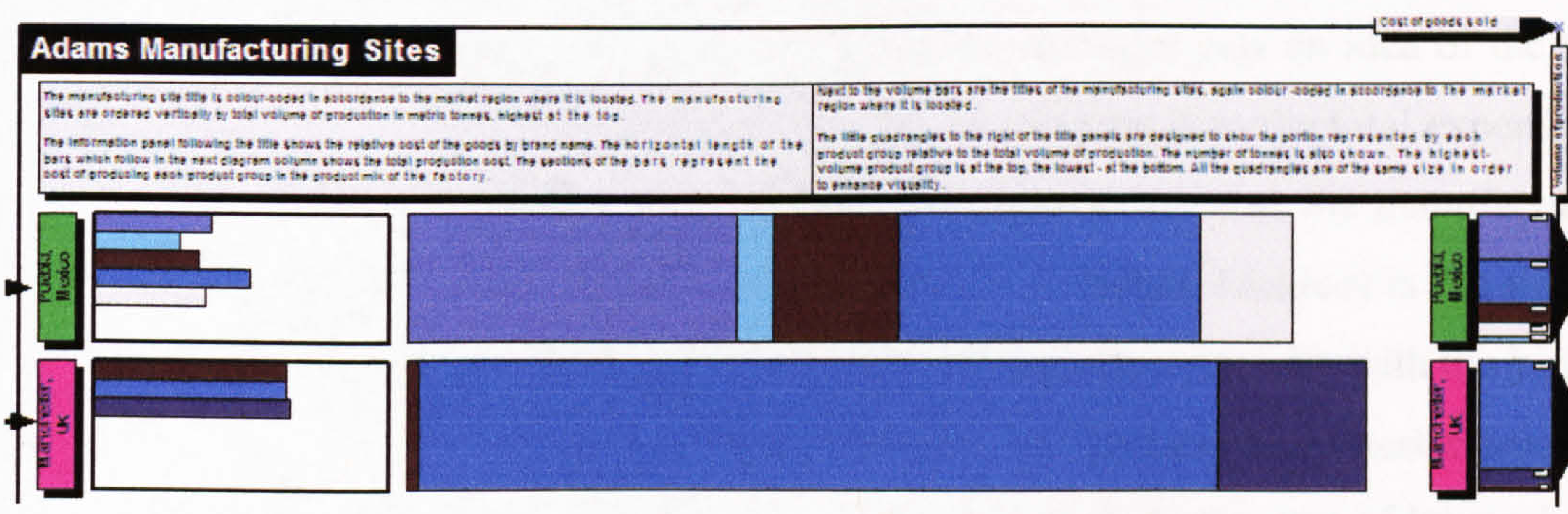

Figure 6.4.5. ***A SAMPLE PART OF THE MANUFACTURING SECTION***

In the next column, there are rectangles which contain information of the cost per metric tonne of production for every product group which is manufactured at the particular site. All the horizontal bars are to scale throughout the whole column, thus enabling the user of the map to compare the production cost at one manufacturing site with the cost at another manufacturing site. This makes it easy to see where in the world it is cheapest to produce a particular product group. Naturally, the data should be treated with caution and should not be interpreted by someone who is not familiar with the regional conditions. The reason is that the comparison is done at the level of product group and not of specific product. The product mix within a product group might be significantly different at one site from the mix at another. The high cost of producing Clorets at the Barcelona site, for example, seems to be an anomaly but once we find out that Barcelona produces sugar free Clorets (whose cost is considerably higher than the cost of the normal Clorets), we know that a comparison with the cost of producing Clorets in Alexandria (which on the map looks quite low) is readily explained. Nevertheless, this part of the map is very useful to spot general tendencies and to compare the general cost of production of a metric tonne of produce at the different sites. The cost of production at Bangkok, Thailand is considerably lower that the price at Cape Town, South Africa. This can easily be explained by low cost of local labour, low local living standards, etc.

The manufacturing sites are ordered vertically by total volume of production in metric tonnes, highest at the top. However, the horizontal length of the bars which follow in the next diagram column shows the total production cost. The sections of the bars represent the cost of producing each product group in the product mix of the factory. Therefore, by looking at the bars, the supply chain manager gets an idea of the total expenditure of producing a product group and can compare it to the total expenditure of producing the rest of the product groups. It is easy to see that the manufacturing site with the highest output (which is at the top – i.e. Puebla, Mexico) is not the one which has the highest total cost of goods sold. The manufacturing site with the highest total expenditure is Manchester, UK (Figure 6.4.5). The fact that Manchester produces more expensive products than Puebla, could be explained by the cost of labour being higher in Manchester than it is in Puebla, local government regulations making production more expensive in Manchester, less efficiency in areas such as production waste, labour utilisation, production scheduling, stock levels and so on. Most probably the reason is a combination of the above mentioned factors. It is up to the user of the tool to investigate the reasons in further detail and to identify areas which can be improved.

The relation between production cost and production volume is summarised in a diagram which is located below the colour coding scheme of the product groups (Figure 6.4.6). The diagram plots a line which represents the total cost of production and the total production volume in the form of bars. This diagram represents the information in the Manufacturing sites section the other way round – it ranks the manufacturing sites by total production cost, making it easy for the global supply chain manager to identify the "most expensive" production sites and to focus the immediate improvement actions on the sites where the possible savings, which could be achieved by optimisation, are greatest.

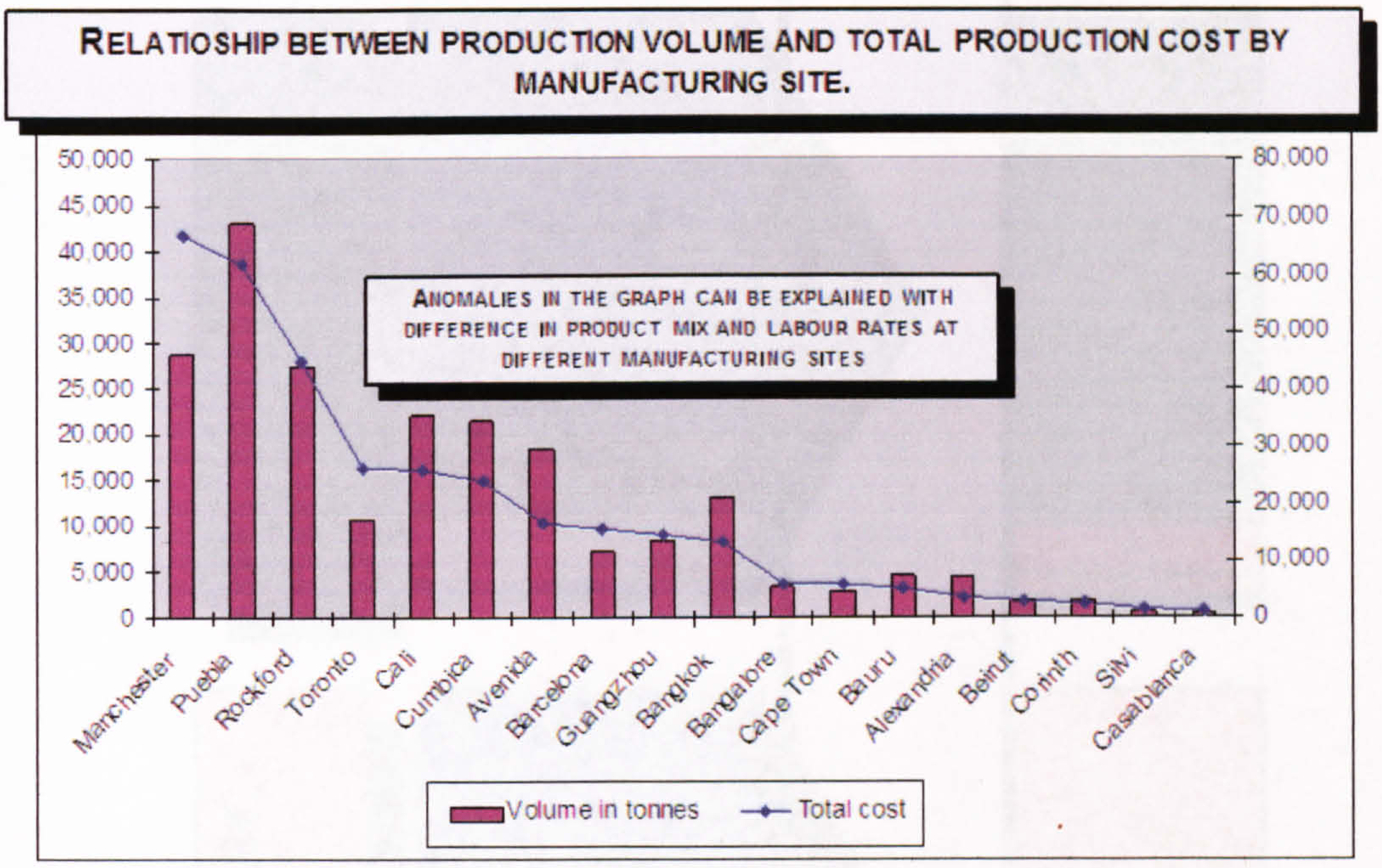

Figure 6.4.6. ***RELATIONSHIP BETWEEN PRODUCTION VOLUME AND COST***

Next to the total cost bars are the names of the manufacturing sites. The purpose of this repetition is to enhance the visibility and help the user of the map identify to which manufacturing site each of the next set of diagrams belongs.

The little rectangles to the right of the title panels represent the volume of each product group relative to the total volume of production. The number of tonnes is also shown in small print – it is done to help the user compare actual volumes and in case more detailed data is required for the particular decision. Another thing which makes it easier to compare product group volumes within one manufacturing site is that the volumes have been ranked. The highest-volume product group is positioned at the top of the rectangle, the lowest - at the bottom. The rectangles for all the manufacturing site are of the same size in order to enhance visibility – this helps identify manufacturing sites with the same product group priorities. For example, we can see that Cumbica and Avenida, which are both in Brazil, have quite different product group mixes – the priority product group in Cumbica is Halls, whereas Avenida specialise in the production of Bubbaloo.

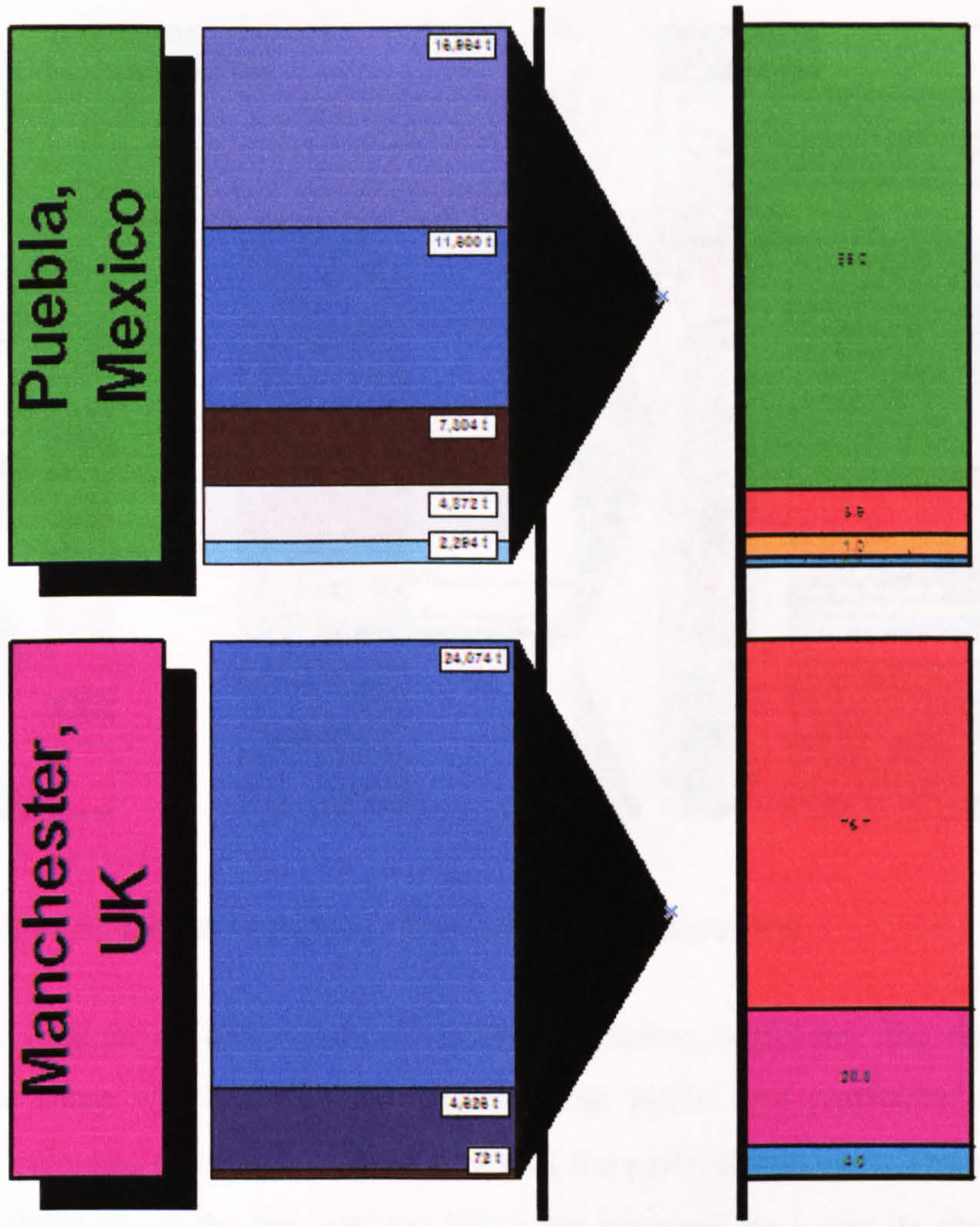

Figure 6.4.7. ***INDIVIDUAL PRODUCT GROUP VOLUME RELATIVE TO THE TOTAL PRODUCTION VOLUME***

The transition to the next section is through arrow-shaped black indicators, as seen in Figure 6.4.7 and Figure 6.4.8.

The Distribution section

The bars in the first column on the left show what part of the total production volume of the site is distributed to each market region (Figure 6.4.8). The market regions are designated using the appropriate colour from the colour code scheme. The number in each of the coloured rectangles which compose the bars show the percentage of the total production output (in volume terms) which goes to the particular market.

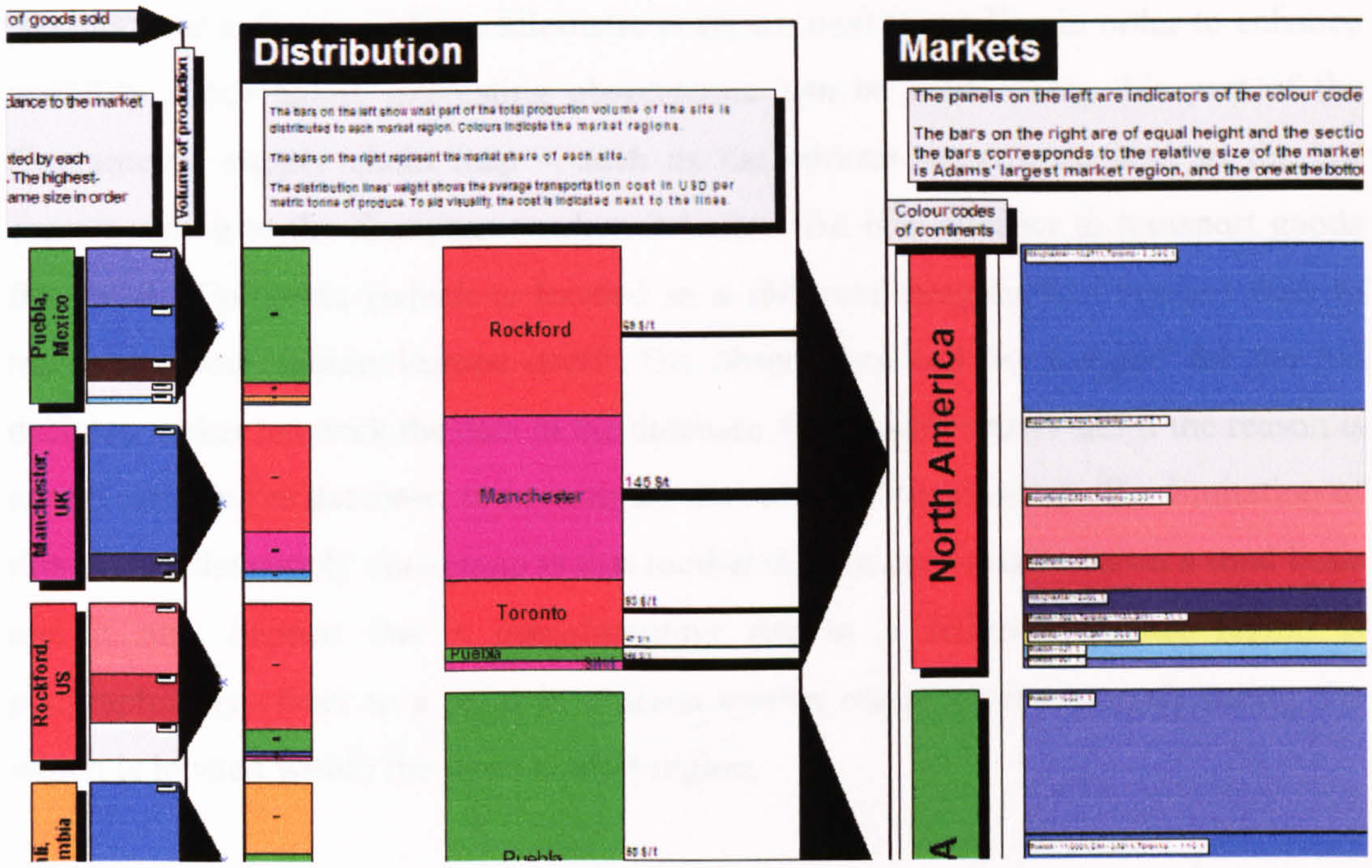

Figure 6.4.8. ***THE DISTRIBUTION SECTION AND ITS SUBSECTIONS***

The second column of bars in the Distribution section represents the markets of Adams. The share which each manufacturing site holds in a particular market is shown by a coloured rectangle within the box of the particular market. The sites with the biggest share are at the top, and the lower the position the lower its share of the market. The location of the manufacturing site is shown in each of the coloured rectangles. It is interesting to observe that most of the markets are supplied by some manufacturing sites which are located outside the market region. This can be explained by two factors: firstly, most of the manufacturing sites belonging to the Adams group are focused on production of only a few specific products, rather than producing the whole product range; secondly, the product which is distributed has high value relative to the transport cost so transport over long distances is not a big issue.

The market bars in the Distribution section are connected to the distribution arrows (which are the transitory points between the Distribution section and the Markets section) via thin black lines. These distribution lines vary in thickness according to the transportation cost for one tonne of product per kilometre (Figure 6.4.8). The more expensive it is, the thicker the line. The transportation cost in USD per metric tonne of product over a distance of one kilometre is shown next to the line in order to enhance visibility. Once again, interesting observations can be made using this part of the diagrametric supply chain map – such as the curious occurrence next to the bar corresponding to the European market: it looks like it is cheaper to transport goods from Cali, Colombia (which is located in a different geographical region) than to transport goods within Europe itself. The observation can be a signal for the SC decision maker to check the data in the database for possible errors and if the reason is not an error in the database, to investigate the reason in more detail. The limitation of this part of the supply chain map is that market regions are considered on a total basis and it may happen that a manufacturing site in a different market region is geographically closer to a point in a given market region than a manufacturing site which is located within the same market region.

The Markets section

The panels in the first column on the left are indicators of the colour code of each market region where Adams' products are sold (Figure 6.4.9). The same colours indicate the respective regions within the whole supply chain map.

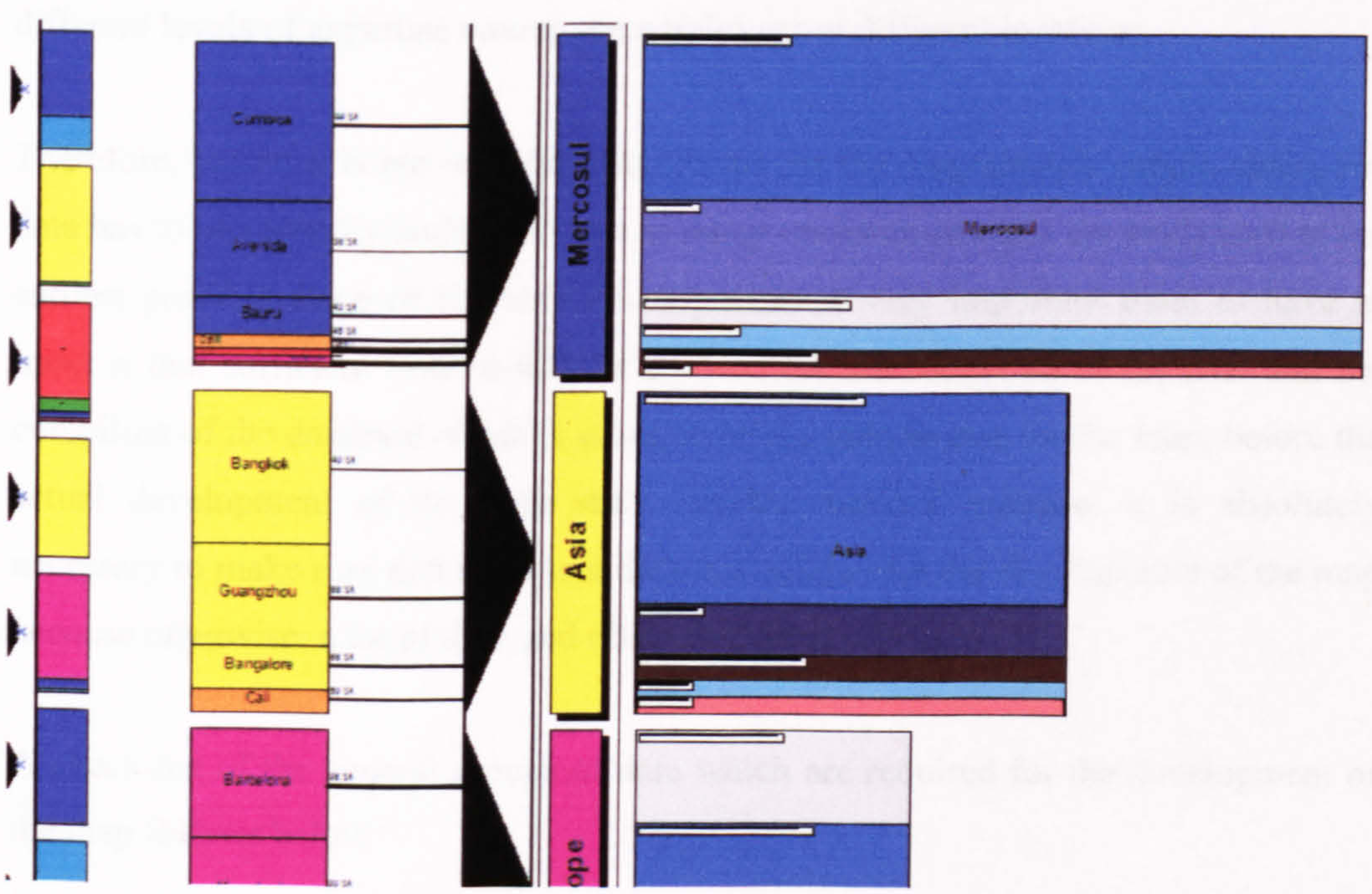

Figure 6.4.9. *THE MARKETS SECTION AND ITS SUBSECTIONS*

The bars on the right are of equal height and the sections within them show the market share of each product group. The product group positioned at the top of the bar has the greatest market share of that particular market. The lower the position of the product group in the bar, the smaller the market share of that particular product group is. Tonnes of annual demand are also shown along with breakdowns of volumes supplied by different manufacturing sites. The length of the bars corresponds to the relative size of the market, measured in metric tonnes. The markets are ordered vertically by size. Therefore, the market at the top (North America) is Adams' largest market region, and the one at the bottom (Andean) is the smallest.

6.4.4 DATA REQUIREMENTS OF THE TOOL

Supply chain analysis and supply chain decision-making require a huge amount of data. Probably the most difficult thing about obtaining the necessary data is that it comes from a wide variety of departments and locations within the company and has to be collated. Other difficulties are caused by the use of different measuring units, different reporting and accounting practices across company divisions, as well as different levels of expertise among the employees at different locations.

Therefore, before it is put into the calculations for the diagrametric supply chain, the data has to be carefully audited so that as many errors as possible are eradicated at the earliest possible stage of the map development. A very important issue to have in mind is that sufficient time should be allowed for the collection of the data and the compiling of the database which is going to be the data source for the map, before the actual development of the map starts. In the authors' opinion, it is absolutely necessary to make sure that sufficient data is available for the development of the map because otherwise, a lot of time and effort could be wasted.

A check-list of the general groups of data which are required for the development of the map follows below:

- Supplier information (a list of names and locations of suppliers)
- Raw materials used in production (a list of names of raw materials)

- Annual purchased quantities by raw material (in metric tonnes per year)
- Annual expenditure by supplier by raw material (in US dollars per type of raw material)

- Transportation costs
- Transportation routes (shipping point – delivery point)
- Transportation times (days in transit)
- Import/export taxes and duties
- Documentation costs

- Number and location of manufacturing sites (a list of names and locations)
- Product range of each manufacturing site (a list of product groups for each manufacturing site)
- Cost of goods sold at each mfg site by product (in US dollars per annum)
- Production volumes at each mfg site by product (in metric tonnes per annum)
- Capacity at each mfg site by product group (in metric tonnes per annum)
- Capacity utilisation by product group (percentage utilisation as estimated by local experts)

- Distribution network structure
- Distribution channels
- Distribution centres (a list of names and locations of distribution centres)

- Markets (a list of names and location of market regions)
- Sourcing mfg site(s) or distribution centres for each market
- Volumes of each product sold (in metric tonnes per annum)
- Sales revenue per product brand name by market (in US dollars per annum)

6.4.5 VALIDATION OF THE SUPPLY CHAIN MAP

Working with raw data is a very tedious task, especially when there are large quantities of data available and when there is the need to weed out the important data from unnecessary detail. Processing data manually, without any automation and without a structured approach (which could easily be inbuilt in a software system), could easily lead to mistakes being made. This makes it necessary to include a special stage in the tool development process – validation of the supply chain map.

Validation needs to be carried out throughout the supply chain map development. This is because in the process of data reduction, the researcher is bound to make a number of assumptions and interpretations of the available data. The ongoing validation has the important task of ensuring that those assumptions are not in conflict with the real situation. Furthermore, the validation will help to keep the development of the model relevant to the specific purpose of supply chain mapping. Last, but not least, the quality control exercised by a knowledgeable business person from the company will help correct any mistakes before they are irreversibly built into the model.

The final validation of the model has the purpose of making sure that the supply chain map is a realistic model of the real-life company operations. This is very important and the conclusions of the validation need to be stated in an official document which will accompany the supply chain. That document should state any reservations that the validating body has and any assumptions that were made during the model development. The reason why such a document is necessary is to make sure that all prospective users of the model will be aware of its limitations and weaknesses so that the user is able to build critical judgement into the decisions he is going to make with the help of the model.

The final supply chain map needs to be validated in a number of ways:

First, the final overview has to verify that the source data has been used for the appropriate purpose. It may happen that a set of data has been used in the place of another set of data (for example, production volumes in the place of sales volumes, cumulative machine capacity in the place of a production line capacity, sales volumes in metric tonnes in the place of sales revenues, etc.).

Sometimes, in the process of development, measuring units are not used properly, for example, thousands are not clearly indicated as such. In the manual process of data conversion from one metric unit to another, mistakes are possible which need to be identified before the model is put into use.

There might also have been errors in the initial data sets. For example, the revenues from one market might have been stated in US dollars whereas the revenues from another market have been stated in GB pounds. If the person compiling the data has made such an error, it may lead to significant deviations of the model from reality. In this case, the validating body needs to scrutinise the model as mistakes of this kind can easily be identified by an expert in the company's business.

6.4.6 UTILISATION OF THE DIAGRAMETRIC SUPPLY CHAIN MAP

After the diagrametric supply chain map was validated by company representatives, it was put to use. A formal meeting was arranged, at which the researcher delivered a presentation to explain the features of the supply chain and the analytical principles that it uses. The meeting was attended by managers of different supply chain functions at various locations within the Adams supply chain. A discussion followed, during which the participants at the meeting were given the opportunity to ask questions and comment on the functionality. All agreed that the only drawback of the map was that it was a snapshot of the situation of the supply chain at a particular moment in time. Real-time data availability and utilisation would be strongly appreciated by all. Therefore, the diagrametric supply chain map needed an automated data input from other company software systems.

With the help of the diagrametric supply chain map, issues were identified in areas as various as procurement, sourcing, deliveries, resource utilisation, manufacturing process, product mix, distribution channels, markets and marketing decisions. Because of that, various departments were involved in the design and approval of the supply chain map, which helped to get everyone together and encourage discussions across functional departments and across whole factories comprising the entire supply chain. During the discussions, everyone could contribute with his or her expertise while still respecting the validity and relevance of the points made by the other participants. Therefore, as well as being an excellent way to provide visibility into the supply chain, the tool proved to be a means of enhancing inter-functional and inter-company communications, thus collaborating greatly to integrating the managerial efforts of supply chain participants.

After the work on the case study was completed, the company management found the resulting diagrametric supply chain mapping tool so useful, that they employed a person to work on the continual updating of the map. The full-time effort on the part of the employee reiterated the benefits that an automated updating would bring to the utilisation of the tool. This conclusion forms a part of the suggested future work resulting from the findings of the dissertation.

6.4.7 SUMMARY AND CONCLUSIONS FOR CASE STUDY 3

In the course of the case study, it emerged that Adams was facing a number of issues with the management of its supply chain. Despite the availability of voluminous data about operations that was available to decision-makers, it was rarely used due to the difficult-to-access format, in which it was stored. This clearly led to the management making a number of, what appear to be, unreasonable strategic decisions regarding the structure of the supply chain and the role of the participants in it. This only emerged after the data was plotted, using the diagrametric supply chain map, developed by the author.

The diagrametric supply chain map is a useful tool which enhances visibility and aids decision-making in the supply chain management process. The trade-offs between detail and simplicity make it mandatory that the user is well acquainted with the specifications of the tool and the way that the original data was used to build it. The user has to be careful not to jump to conclusions that are based only on the global view of the supply chain – common sense and experience should be used together with the tool to make sure that the conclusions are not distorted by the limitations of the analytical tool. This was demonstrated in the analysis of the data, used to construct the model of the diagrametric supply chain man – the author highlighted possible inefficiencies in the structure and functioning of the supply chain, which could also be resulting from the inability of the tool to provide both a global overview and a detailed analysis of the supply chain parameters.

However, despite its limitations and implied generalisations, the tool is an excellent means to observe the major characteristics of the mapped supply chain. The author strongly believes that the proposed novel way of viewing the supply chain will bring huge benefits to supply chain managers who adopt it in their practices by enabling them to view their entire supply chain from a new perspective. Besides providing an excellent basis for analysis of the existing supply chain and planning for its activities, the tool can assist in strategic decision-making if the map is built on the parameters of the supply chain changes that are considered for implementation.

This case study achieved all of the objectives which were stated at the beginning of the case study work. Furthermore, a number of unexpected findings helped to confirm other aspects of the entire research project. Overall, the results from the case study justified the time and effort involved both in terms of benefits for the research and in terms of benefits derived by the collaborating company.

	Manchester	Dublin	Barcelona	Silvi Marina	Corinth	Beirut	Alexandria	Casablanca	Cape Town	Vichy	Toulouse
MPS/Net Requirements , MPS ordered, MPS filled	SAP	Excel	SAP	PRISM	PRISM	PRISM	Excel	Excel	Manugistics CPP/Prism	PMIcs	PMIcs
Capacity (by packing) in stat units	Excel	Excel	Excel	PRISM	Excel	Excel	Excel	Manually	Excel	Excel	Excel
Plant Inventory (by packing)	SAP	PRISM	Excel	PRISM	PRISM	PRISM	Local software	Manually	PRISM	PMIcs	Excel
Cost of Goods	SAP	PRISM	SAP	PRISM/JDE	Excel	PRISM	Excel	Excel	JDE/Prism	PMIcs + COMPUTRON	Excel + COMPUTRON
Current Year Operating Plan Exchange Rate	Intranet	Intranet	Excel	JDE	Excel	SER (Ireland)	Intranet	Intranet	Intranet	Intranet	Intranet
Demand/orders	Manugistics, Excel, SAP	Excel, Prism	Excel, SAP	Excel	PRISM-OUTLOOK-DRP	Excel	Local Software (Al Motammem)	Manually	Manugistics, PRISM	Excel,PMIcs	Excel,PMIcs
Master production schedule	SAP	Excel	Excel	PRISM	EXCEL-PRISM	PRISM	Excel	Manually	Manugistics	PMIcs	Excel
Capacity evaluation	Excel	Excel	Excel	PRISM	Excel	Excel	Excel	Manually	Manugistics, Protean Planning	Excel	Excel
MRP	SAP	Excel	SAP	PRISM	EXCEL-PRISM	Excel	Excel	Manually	Protean Planning	PMIcs	PMIcs
Vendor schedules	SAP	Excel	SAP	PRISM	EXCEL-PRISM		Excel	Excel	Protean Planning, Avantis Procurement	PMIcs	Excel,PMIcs
Production recording	SAP	Excel & Prism	SAP	PRISM	EXCEL	PRISM	Excel	Excel	PRISM	PMIcs	Excel
Warehouse management	SAP	PRISM	SAP	PRISM	EXCEL-PRISM		Local Software (Al Motammem)	Locally developped software	PRISM	PMIcs	PMIcs
Shipping	SAP	Prism, Word & Excel	SAP	AS400	PRISM	PRISM	Local Software (Al Motammem)	Locally developed software	JDE, PRISM, Avantis Procurement	PMIcs	PMIcs
Invoicing	SAP	Prism, Word & Excel	SAP	JDE	PRISM	PRISM / EXCEL	Local Software (Al Motammem)	Locally developed software	JDE, PRISM, Avantis Procurement	PMIcs	PMIcs
Financial reporting	SAP	JDE, Dataplus	SAP	JDE	Excel	JDE	Local Software (Al Motammem) - Excel	Excel	JDE	Excel,PMIcs	Excel,PMIcs
IS Contact: Name/Phone	Mike Bell +44 161 767 2228	Frank Kenny 353-1-2049240	Fina Andrade +34 93 4799600	Giuliano Mariani +39-085-9367243	Yiota Petousi +30 1 2704054	George Khalil 961 9 211818	Farid Shehata + 203 438 0373	Abdellatif Rifki (212)22 234621	Reg Neethling (27 21 710 4255)	Yves Fenille 33470309497	

Figure 6.4.10. ADAMS IT INFRASTRUCTURE

Like the previous two case studies, the third case study showed that the collaborating company was not utilising any software system for managing its entire supply chain. However, in this case study, the finding was entirely unexpected. Being a large international company with a very well developed global supply chain, it was assumed that Adams would be using particular supply chain management software throughout the entire company. It was also surprising to find out that the integration of the whole supply chain was rather poor in that communication and data exchange were reduced to the bare minimum. Tools and methods for supply chain management existed but they were local solutions which were not integrated and did not take into account data from other parties in the supply chain. As can be seen from Figure 6.4.10, even localised management systems were fragmented with different departments using software tools of their own, entirely independent from the systems used at other departments within the same factory. Furthermore, the software solutions, which are used, can not be considered to be "supply chain management" tools – they are mainly software packages for recording data (Excel). Reporting functions exist in some of them (some factories have developed such features in Excel; SAP and Prism also have reporting modules; supply chain analysis can be aided by some of the functions in JDE), however, features such as optimisation and planning are not supported by any of the software packages utilised by the factories within Adams.

The above conclusions show that supply chain management tools and methods are not only unavailable at small and medium-sized companies. The case study company, being a large multinational establishment, is a typical example of how a complex supply chain is managed without software tools to aid the decision-making and planning process. These findings confirm what has already been suggested by the literature and supported by the case studies and expert interviews that the majority of today's companies do not utilise the tools and methods available on the market for supply chain optimisation and integration.

The case study helped elaborate the research model of the advanced supply chain management tool by adding further functions and capabilities to it. Providing visibility into the supply chain is the most important feature of the supply chain management tool that higher level supply chain managers need in order to understand the way the supply chain operates. Thus it is a prerequisite for taking quality decisions regarding the structure of the supply chain and the management of the day-to-day operations. The improved visibility needs to be both in terms of the global picture of the supply chain, meaning the basic supply chain parameters, as well as in terms of detail, meaning ability to zoom into the parts of the global picture to obtain reliable detail that is unaffected by the simplification of the global view.

The case study helped confirm the conclusion that the data that the supply chain management tool uses needs to be timely, using real-time data collection. This is a great challenge to the existing supply chain management tools since, in order to collect data in real-time, the software needs to be integrated with modern technologies such as Radio Frequency Identification (RFID) (mainly used for asset tracking and location within the manufacturing unit), Global Positioning Systems (GPS) (for location in transit), the Internet (to transfer the data from remote locations to the central database). Apart from the additional costs involved in installing and maintaining the real-time data collection system, the challenge will be to ensure data compatibility between the inputs from the different locations. Even if real-time data availability were not affordable, especially by smaller companies, the supply chain management tool would benefit enormously from the ability to be updated easily with the latest data available from the various locations of the company. Apart from employing the Internet for fast data transfer, an existing intranet, or EDI system, the software will need to update the supply chain map automatically so that the diagrametric representation of the supply chain remains up-to-date and relevant for the current supply chain management decisions that need to be made.

The case study led to the conclusion that currently, the market is unable to provide the functionality required by the supply chain management of large international organisations, such as Adams. The various local tools and systems that were used at the time of the case study had insufficient functionality to cater for the need of visibility into the complex structure of the supply chain. Besides that, the tools did not exceed the requirements of separate functional areas within supply chain management and thus did not offer any scope for inter-functional integration. The IT infrastructure of Adams looked more like a patchwork of disparate pieces of software which could not communicate easily with each other within the factories, let alone achieve any inter-factory communication. If Adams were to look into deploying a global supply chain management tool, they would have to start from a global overview of the supply chain management process and expand that into the various manufacturing sites, then further down into the separate functional areas within each one of them. A tool that would provide the required global visibility into the supply chain was the tool whose prototype was developed during the work on the case study.

6.5 GENERAL DISCUSSION AND CONCLUSIONS

The chapter dealt with three case studies in manufacturing companies of different sizes and with different supply chain structures. In all of them, the research effort was focused on addressing the main problems of the research project – that is, to identify whether or not the particular company was utilising any advanced supply chain management software and if not, what were the ways and means the management had to carry out their supply chain management tasks. The findings were used to identify ways to help the company address their current supply chain management issues and to come up with a solution which would fit their operations and budget. The latter contributed to the specification of an advanced supply chain management system, which is going to be discussed in the next chapter.

The table in Figure 6.5.1 provides a summary of the three case studies. It indicates the main focus of the particular case study and the objectives set out for it at the beginning. The deliverables of all case studies are described, as well as the ways in which the case study companies benefited from the projects. The significance of the output from the case studies is described, which leads to the conclusions derived in view of the research objectives as set out at the beginning of the thesis.

	Case Study 1	Case Study 2	Case Study 3
Supply Chain Focus	Supplier Relationship Management	Process modelling, significance of demand and capacity planning	Supply chain mapping
Objective	To gain an overview of an SME's supply chain; To study the tools it uses for managing it; To explore the case study company's supplier management practices; To develop and implement a bespoke tool for SRM.	To gain an overview of a small manufacturing company's supply chain; To find out what tools are currently used to manage the supply chain; To simulate the operations on the shop floor in order to explore their implications for the entire supply chain.	To gain an overview of a large multi-national company's supply chain; To study the supply chain management tools and methods currently used for managing the supply chain; To develop a tool for providing visibility into the global supply chain.
Project output	VenPAC – a bespoke system for supplier performance assessment and classification	Shop-floor simulation model. Detailed process maps.	Diagrametric supply chain map
Significance	Enhanced visibility into the supplier base of the company; Automated reporting and supplier classification based on various performance factors.	Enhanced visibility into the shop floor operations proved that the manufacturing process was not aligned with the complexity of demand and capacity planning; Highlighted the importance of improved communications between shop floor and management.	At-a-glance view of the global supply chain; Enhanced analytical tool, providing sufficient detail to enable strategic decision making.
Benefits for the case study company	Reduced supplier base; Enhanced reporting and analysis of the remaining suppliers; Savings on total procurement expenditure.	Improved management understanding of shop-floor processes; Enhanced shop floor scheduling.	Improved supply chain management decision-making process; Aids management in making strategic, as well as operational decisions.
Conclusions	Off-the-shelf supply chain management solutions are unpopular among small and medium-sized companies; Visibility in the supplier base can be enhanced greatly by implementing a simple low-cost analytical tool which makes use of data that is already available within the company; Supply chain management tools are affordable by companies of all sizes and budgets.	No use of supply chain management tools could be observed within this case study company; Advanced supply chain management tools need to provide guidelines for capacity planning and scheduling depending on demand patterns; Communication between management and shop floor needs to be a two-way, continuous process; Advanced supply chain management tools should facilitate both intra-company and inter-company communication.	No advanced supply chain management system was utilised by the case study company on a global level; An analytical tool to represent the structure of the entire supply chain is absolutely necessary to enable efficient decision-making; The data used for decision-making should be up-to-date, preferably real-time. An advanced supply chain management tool should help integrate the supply chain.

Figure 6.5.1. CASE STUDY SUMMARY

The conclusions that are common for the three case studies and are relevant to the main focus of the research, can be summarised as follows:

- Off-the-shelf supply chain management solutions rarely prove to be a good fit for the requirements of all the functions and departments in industrial companies of all sizes and in different industrial sectors. This fact can be explained with the specific requirements that each company's supply chain imposes on the functionality of an efficient supply chain management tool. Bespoke solutions prove to be a better fit for industrial companies – both in terms of functionality, ability to integrate the supply chain, and cost;

- An advanced supply chain management tool needs to offer functionality in all areas of the supply chain in order to help make coherent decisions, relevant to the problems of the entire supply chain, rather than a specific part of it;

- Supply chain management tools need to provide both an overview of the entire supply chain, and the ability to "zoom" into specific areas. The first is necessary to make sure that problems are solved, not shifted to other parts of the supply chain. The latter is crucial to avoid global decisions being based on summarised information and assumptions made during the process of summarising it;

- An advanced supply chain management tool can only perform to the expectations of its users if it utilises up-to-date, real-time data from the supply chain.

CHAPTER 7 – IMPROVED SUPPLY CHAIN MANAGEMENT (ISCM) TOOL SPECIFICATION

7.1 INTRODUCTION

The present chapter will summarise the conclusions drawn from the survey, the expert interviews and the case studies described in the previous chapters by recommending a model of an improved supply chain management (ISCM).

The model will be developed and described in detail, suggesting further development and research opportunities. Based on the tool specification provided in the present chapter, software development work can be carried out in order to implement some of the suggested improvements regarding the functionality of an ISCM software tool.

7.2 ISCM TOOL SPECIFICATION

This section will describe the specification of an SCM tool. It will start with summarising the requirements of the tool, as identified in the previous chapters. Following that, the issues of designing a tool that satisfies those requirements will be discussed and a number of ways, in which those issues can be addressed, will be suggested. The section will proceed with the design of a local ISCM system, based in a single company, which is needed as a basis for the supply-chain-wide implementation of an ISCM system. Following that, a way to achieve supply-chain wide optimisation and integration will be suggested, building upon the structure described on a local company level. Finally, it needs to be demonstrated that the tool will assist at all levels of decision-making: strategic, planning and execution. Overall, the section will explain the functional units of an ISCM system and the interactions between them.

7.2.1 ISCM TOOL REQUIREMENTS

The previous chapters of the thesis brought forward a number of issues related to currently existing SCM systems. They also indicated what additional functionality is necessary in order to assist the decision making process related to SCM problems and the SCM process as a whole. As a conclusion, it was identified that any tool, developed to meet the future requirements of the supply chain management, needs to achieve or enable the following:

- It needs to optimise the functioning of the supply chain, where optimisation means helping to make a decision, which is the optimal decision for all parties in the supply chain, rather than for a single participant;

- It needs to be able to aid in the making of strategic, rather than just execution, decisions that are relevant to and consistent with the future plans of the companies involved;

- It needs to use timely, close to real-time data sourced from all the parties in the supply chain;

- It needs to provide visibility into both the big picture and the smaller details of the supply chain;

- It needs to enable management decisions to be based on automated and intelligent exception management;

- It needs to enable item-level demand planning;

- It requires sales forecasting and demand management functionality;

- It should have functionality to enable replenishment and supply planning with key trading partners for critical product categories;

- It needs to enable bidding and negotiation between the partners throughout the supply chain.
- It needs to enable collaborative planning, as well as scheduling and management in collaboration with third parties;
- It requires supplier relationship management functionality;
- It requires order management and fulfilment functionality, synchronised with demand and capacity planning;
- It has to enable real-time dynamic scheduling of materials and production;
- It needs to assist in transportation planning for minimum cost;
- It needs to have functionality that provide network design and optimisation capabilities, as well as network capacity management;
- Overall, an ISCM tool needs to offer functionality in all areas of the supply chain in order to help make coherent decisions, relevant to the problems of all operations within the supply chain.

7.2.2 THE ISSUES

An ISCM tool has to cater for the needs of all the companies along the supply chain, all their divisions, operations, and functions. A part of the problem with implementing such a system would be obtaining the data which is necessary for the system to function. The problem is made even more challenging by the requirement that the data be real-time or near real time. The latter can only be achieved by employing sophisticated data collection systems, such as RFID, RTLS (Real Time Location Systems), GPS, GLS (Global Location Systems). Such systems are already available on the market and successful implementations are not rare, with the latter increasing in number every day. However, the challenge is for a company which is not using either a SCM system, or a data collection system, to invest in the implementation of both of them at the same time.

Due to the complexity of the matter, very little has been done to integrate the above technologies and build applications that combine them in order to complement their strengths. A solution, using one of the technologies, typically comes with a software application that only manages the data acquired through the particular data collection technology. Solutions, where that data is fully utilised by the main enterprise management system, currently do not exist. The problem is made worse by the fact that, for a SCM to function to its full capacity and to achieve its full benefits, one company in the supply chain is not enough to implement it. Synchronising the implementation of the SCM system by all the companies along the supply chain is a very challenging task to achieve.

Even if the members of the supply chain have the necessary resources to ensure that real-time data is available, there are other obstacles that need to be overcome in order to achieve the desired improved functionality of a SCM tool. However, the obstacles and risk factors are not the subject of the current dissertation – those could be suggested for future research. The focus needs to be placed on the specification of a fully-functional tool for improved SCM.

The specification of an ISCM application will need to adapt existing solutions to today's Internet-based world through changes in functionality, technology, and architecture. The most apparent change from existing SCM systems to an ISCM tool is a change in focus from one that is totally enterprise-centric and focuses on internal resource optimisation and transactional processing to a new focus on process integration and external collaboration. All existing information technology capabilities that are centred on the enterprise will have to be extended internally and externally to the entire supply chain.

Internally, ISCM software will need to integrate separate and disparate systems so that business processes can be connected in a manner that is seamless and transparent to the end users. The overall result will be a free-flow of information throughout the supply chain. A single program interface will be the end-user contact point for all the separate systems residing in different locations, allowing it to be modified in a manner that does not corrupt or violate data integrity.

These actions will, depending on process requirements, trigger events in any of the systems to which the data is returned. The action will result in a chain of programmed events that will be immediately visible to other users of different applications or systems.

Furthermore, the information that is exchanged when two or more businesses exchange information electronically via the Internet will be made available to all the parties throughout the supply chain. The applications, process, and data of all collaborating businesses will thus be integrated and loosely connected to facilitate near real time sharing of business data. Whenever a member of the supply chain needs a particular resource from their supplier, they will be able to do a direct query on the supplier's systems to locate the resource availability. This action will be carried out directly over an existing supply chain wide network or a secure Internet connection. Information will be readily available for alternative suppliers of the resource, lead times, costs and the terms and conditions that would apply to the transaction. The ISCM tool will also estimate (based on artificial intelligence principles) the most appropriate supplier to be used in the specific case. All alternative suppliers will receive feedback and given the opportunity to improve their strategies, should they find it appropriate.

Using similar optimisation tools, the suppliers themselves will base their decisions on transparent information from their own suppliers – the ISCM system would even be able to suggest improvements in the strategies of the company.

An ISCM tool, working with complete and transparent set of data, would be able to recommend the most suitable role for each party in the supply chain. For example, suppliers with low production capacity would be suitable for undertaking the manufacturing of the more sophisticated, customized products in the supply chain, they would specialise in design and new product development, whereas companies with abundant production capacity would undertake mass production of already established, high demand goods. In today's supply chains, these strategic decisions are based on intuition and observation, involving high risk and necessity of expensive market and industry research. In the world of optimised supply chain management solutions, such data will be readily available and reliable, enabling all the members of the supply chain to build on their strengths. Within the supply chain, relationships will be purely collaborative and cooperative, with open and unobstructed information flows. This would also enable the members of the supply chain to agree a common, coordinated strategy and avoid the competitiveness that disparate strategies would result in.

Given today's state of development of technology, the achievement of such an optimised supply chain is hardly as utopian as it looks. Most world-class companies have already recognised the importance of real-time data for operational and strategic decision making. Automated identification systems using RFID, bar-coding, GPRS and GPS are already in place worldwide. Data from point-of-sale is passed automatically onto planning and purchasing to immediately replenish depleted stock levels.

It is only the lack of inter-company data transparency and trust between the members of the supply chain that stops that data from being available all the way up and down the supply chain. Because nowadays, wherever present, real-time data is typically only available within the boundaries of a single enterprise, it is only out-of-date, reduced data that is passed onto other members of the supply chain. The reason is that companies feel more confident keeping sensitive data, such as costs, to themselves. However, they fail to see beyond the boundaries of their own company's interests and realise that in that way, they only contribute to the build-up of inventories, and, ultimately, costs, throughout the supply chain, resulting in the end product being less competitive than it could be.

To enable real-time data availability, items throughout the supply chain will be tagged with electronic devices that store identification information. These devices are activated by magnetic fields and use radio frequencies to communicate with systems that are connected to a receiver network throughout the company. At all times, everyone inside and outside the company, including the original suppliers and customers, will be able to see the location and status of every part that makes up the end product.

This information is not only shared by people, but also modules that comprise the advanced supply chain management system, such as advanced planning and scheduling, customer relationship management, supplier relationship management, warehousing and transportation management, inventory management, logistics management, finance and accounting, and human resource management.

This results in a heavy impact on business, application, and technology strategies. The traditional role of enterprise management systems becomes expanded to now include publicising IT capabilities in order to facilitate interoperability and collaboration between functions, as well as between companies. The domain of the information system will no longer be limited to disparate functions, but will expand to include all functional areas of the supply chain.

The function of the ISCM tool, therefore, also expands to include other functions that are specific to individual industries and sectors, such as utility customer billing, air traffic control, or even disease control. This is where the implementation of an ISCM tool enables business ecosystems to achieve new levels of efficiency through event driven processes that are exactly tailored for unique environmental and customer requirements.

7.2.3 THE LOCAL DESIGN OF AN ISCM SYSTEM

In designing an ISCM system, the first main issue that needs to be addressed is how to distribute the tasks across the modules of the system. In most manufacturing organisations, the operations, which constitute the entire manufacturing process, are distributed across the departments of the company. This enables the specific department to specialise in one particular area of skills and to be held responsible for the decisions that need to be made in relation to that area, as well as for the execution of the tasks that fall into the area. An ISCM tool, likewise, needs to distribute the tasks across its modules. The main decision-making unit will be responsible for sending requests for information to the modules and reconciling incompatible solutions, achieving the optimum solution for all the modules. However, day-to-day, execution information need not be shared across the entire network and should be stored within the module only for its specific decision-making needs. An ICSM tool will typically need the following modules:

Order Management Module

This module is responsible for receiving orders from customers; negotiating specifications, prices, order due dates. It will also manage the process of handling customer requests and the information resulting from them. It will also be responsible for modifying or cancelling their orders.

Logistics module

This module is responsible for coordinating the plants, suppliers, and distribution centres in the supply chain to achieve the best possible results in terms of the common goals, including on-time delivery, cost minimisation, inventory minimisation. It manages the movement of products or materials across the supply chain from the supplier of raw materials to the customer of finished goods.

Transportation module

This module is responsible for the assignment and scheduling of transportation resources to satisfy interplant movement requests specified by the logistics module. It can consider a variety of transportation assets and transportation routes.

Scheduling module

This module is responsible for scheduling and re-scheduling activities in the factory, exploring possible "what-if" scenarios for potential new orders, and generating schedules. It assigns resources and start times to activities while at the same time optimising certain criteria such as minimising work in progress or downtime. It can generate a new schedule or repair an existing schedule that has violated some constraints.

Resource module

The resource module merges the functions of purchasing management, inventory and capacity management. It dynamically manages the availability of resources so that the schedule can be executed. It estimates resource demand and determines resource order quantities. It is responsible for selecting suppliers that minimise costs and maximise delivery. This module generates purchase orders and monitors the delivery of resources.

Despatch module

This module performs the order release and executes real-time shop-floor control functions as directed by the scheduling module. It operates autonomously as long as the factory performs within the schedule set by the scheduling module.

Figure 7.1. illustrates the way, in which the modules of the ISCM tool interact with each other. The model explains the process of decision-making within the ISCM system and how the impact of changes in the environment flows through the system network.

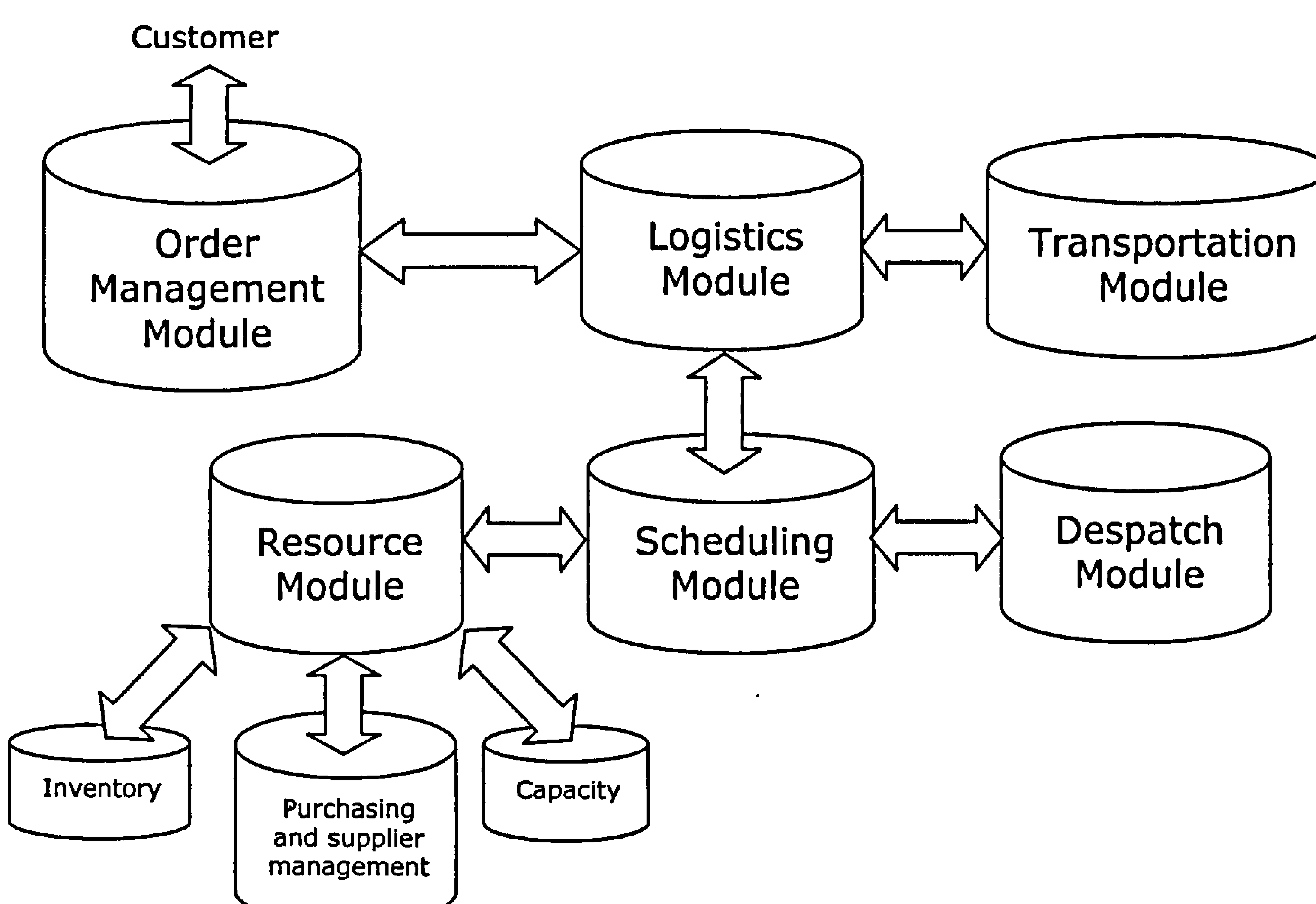

Figure 7.1. *INTERACTION BETWEEN THE ISCM MODULES ON A LOCAL LEVEL*

When a customer order is placed or changed in the order management module, that change is communicated to the logistics module. If plans violate constraints agreed with the customer (such as due date), the order management module negotiates with the customer and the logistics module for a feasible plan.

The logistics module passes on the requirements resulting from the agreed customer order to the transportation module and the scheduling module. The transportation module schedules all transportation activities related to the particular customer order, taking into consideration existing schedules and due dates. The result is communicated back to the logistics module and it negotiates it with all the other modules to achieve an optimum solution.

The scheduling module allocates tasks, related to the customer order, to the despatch and resource modules. The resource module feeds back information about whether or not the available capacity is adequate to complete the order within the agreed time scale. This includes considering data from the inventory, purchasing and capacity sub-modules. The purchasing module can negotiate availability of resources from the existing suppliers and request quotes for varied lead times and specifications. If resources are not adequate or do not arrive as expected, the resource module assists the scheduler in exploring alternatives to the schedule by generating alternative resource plans.

When deviations from the schedule occur, the despatch module communicates them to the scheduling module for repair. Given agreed degrees of freedom in the schedule, the despatch module makes decisions as to what to do next. In doing so, the despatch module must balance the cost of carrying out the activities, the amount of time involved, and the uncertainty of the factory shop-floor.

The entire decision-making process needs to be totally transparent to all the modules within the ISCM so that 1) all modules can use any data that is available within the network of modules; and 2) all problems can be communicated back to the module where they can be resolved. The process is an iterative, dynamic decision-making, with no single solution available at any one time – any module within the ISCM is always ready with a number of what-of scenarios and alternative solutions to its area of expertise, listening to the other modules for changes in circumstances.

7.2.4 ACHIEVING SUPPLY CHAIN WIDE INTEGRATION AND OPTIMISATION

The second issue in designing an ISCM is achieving true and seamless coordination among modules. The dynamic nature of the supply chain makes coordinated behaviour an important factor in its integration. To optimise supply-chain decisions, a module cannot make a locally optimal decision but must take into consideration the effect its decisions will have on other modules and coordinate with others to choose and execute an alternative that is optimal over the entire supply chain. The problem gets more challenging to address by the random events generated by the flow of new objects into the supply chain. These can be customer orders, new customers, shipments of material from suppliers, and new suppliers themselves. Changes in customer orders, inability of suppliers to deliver the required resources, various disruptions in the manufacturing process, machine breakdown all drive the system away from any existing schedule. In dealing with such unpredictable events, the modules must make optimal decisions based on complex globally agreed criteria that may be contradictory and therefore require trade-offs. There should also be a pre-defined level of acceptable compromise with otimisation for cases where there is not enough time for the modules to calculate all available options and negotiate them between themselves. A "cut-off" point will also need to be carefully pre-set in the system, meaning that beyond it, all plans and schedules turn from flexible to fixed. The determination of this point will depend on many factors and will be suggested as a subject for further research.

Although an ISCM system will be able to achieve an optimum solution with reasonable independence from human input, it should acknowledge that humans are privileged members in the organisation. This results in the requirement that ISCM systems offer interactivity while still being prone to human error that would result in inconsistencies throughout the system. Coordination and negotiation between the modules must take these issues into consideration as well, in addition to the computational cost, complexity, and accuracy of the algorithms used.

Another potential problem in negotiating between modules is that a module may come up with a number of equally viable options and, because it has to choose one of them, the one that is selected may not offer as good an opportunity to the other module as another of the available options. If the module receives one solution, it would assume that that is best trade-off for the other module and will try to work around it, not being aware that another option, which is as good for the other module as the one suggested, will offer it the potential for a better trade off. That is why the need arises to either "teach" each of the modules what the other ones would consider as a better option, i.e. develop an optimal algorithm, or to simply pass on all the options that offer similar trade-off. The problem with the first way of overcoming the issue is that modules will need to consider other module's factors in their own decision-making, which diffuses the autonomy of the modules and complicates the optimisation algorithms that the modules need to use. The drawback of the second way of addressing the issue is that the communication stream between the modules will increase in volume and has the potential of growing exponentially through the ISCM decision-making process - in case a module is not able to choose one of the options that were passed onto it, it will have to pass all of them to the next decision-making node, each coupled with the number of options it comes up with. Selecting the exact way in which the issue should be tackled will depend on the sophistication of the software program that will be written and the amount of data transfer that the particular system specification can handle. Other ways to solve the issue could be the subject of further research.

In summary, in order to fulfil all the requirements of an ISCM system, the tool needs to satisfy the following functional and structural conditions:

- The functions of supply chain management must be divided among a set of autonomous software modules.

- Each module must perform its functions continuously.

- Each module is built around a full capability to manage its function and uses appropriate optimisation methods for decision-making.

- Each module must understand the restrictions of other module and can access the functional capabilities of other modules and their operational data.

- Each module can get support from other modules and can offer solutions to them if requested. This means that every module must be aware of the specific capabilities of the other modules.

- Each module must be able to react to events as they occur, modifying its behaviour as required in a flexible manner.

- Each module can cooperate with other modules in finding the optimal solution to a problem. The cooperation can be dynamic, i.e. both modules work simultaneously, combining resources and expertise, or passive – each module waits for the other one to offer a solution which it then tests and modifies, returning it to the first module for further testing and development.

- Each module must be flexible to allow human interaction in the way it makes decisions – both in the input of data and in making the conclusions from the available data. Authorised users may override the actions and decisions of the system at any point and time without disrupting the performance in other parts in the system.

- The total functionality of the modules must span the range of functions required to manage the entire supply chain.

- All the modules need to be able to quickly adapt to the changing needs of the organisation. For example, adding a resource, modifying the product range, changing the pricing, inventory or service policy should be quick and straightforward for the user to do.

The notion and structure of an ICSM system module needs to be explained further. Each module within the ICSM will carry out a set of separate functions in order to carry out its responsibilities within the ICSM system. Therefore, it will need to have a number of separate functional sections, which will be introduced as: Database, Database Manager, Data Analysis Tool, and Inter-modal Relations Manager. The way in which they interact and link together to comprise a module is illustrated in Figure 7.2. and explained below.

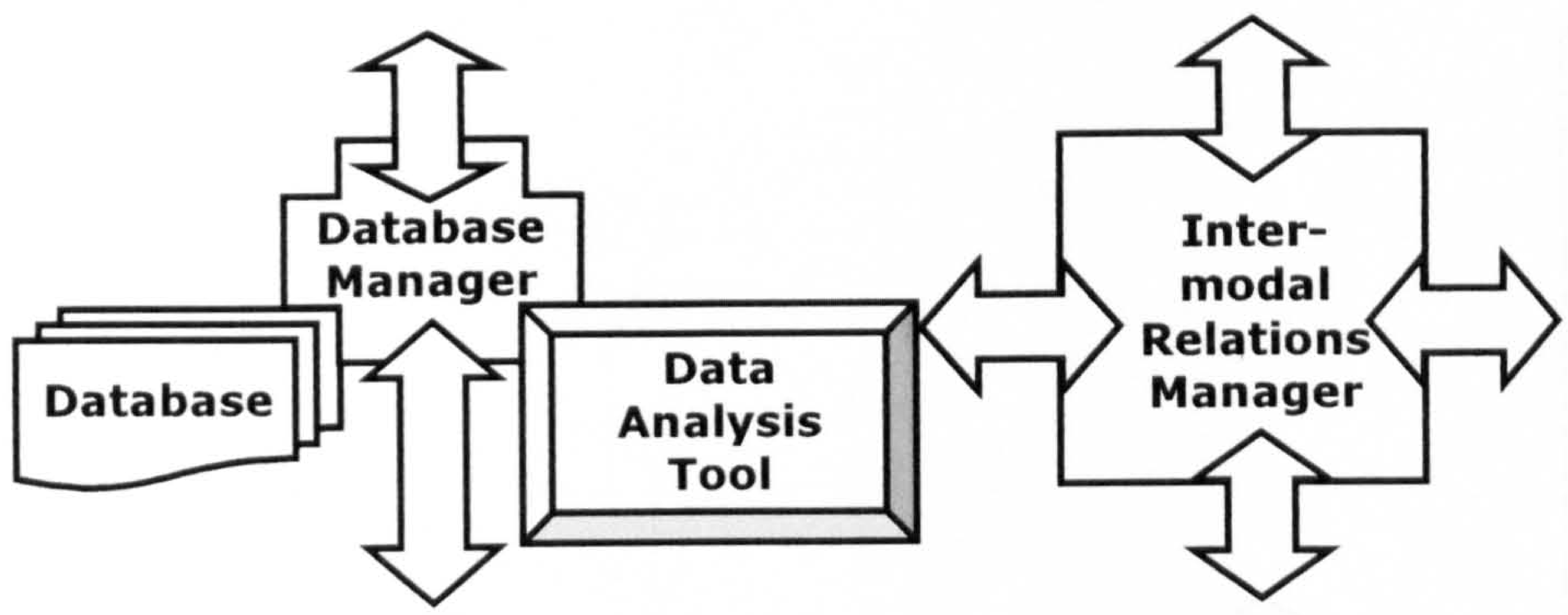

Figure 7.2. *STRUCTURE OF AN ISCM MODULE*

The Database stores all the local data that is recorded during or received from day to day transactions and serves for data input into the decision-making tool. The Database, therefore, interacts will day to day operations and powers the end-user interface for the purposes of recording / monitoring daily transactions. The Database Manager maintains the consistency of the data in the modular database by comparing it with the data used by other modules in the ISCM system (as shown in Figure 7.3.). For example, if a new supplier is registered in the supplier relationship management module, the Database Manager in the Resources Module will update the list of raw materials to include the materials that are to be sourced by the new supplier. The Database Manager also communicates with other Database Managers to retrieve and send data that is required for a particular decision-making process and is not stored locally.

The Data Analysis Tool is the modular decision-making tool – it analyses the data that is stored locally together with the data that is retrieved by the Database Manager in order to come up with a scenario (or a set of scenarios) that would comply with its rules and achieve its objectives. The Inter-modal Relations Manager takes the scenario (or scenarios) and negotiates them with the modules that are directly related to it in the structure of the ISCM system. Two separate modules would interact on two levels – transactional (via the Database Manager, for exchanging necessary data) and strategic (via the Inter-modal Relations Manager, for exchanging information about modular decision-making scenarios), as shown in Figure 7.3.

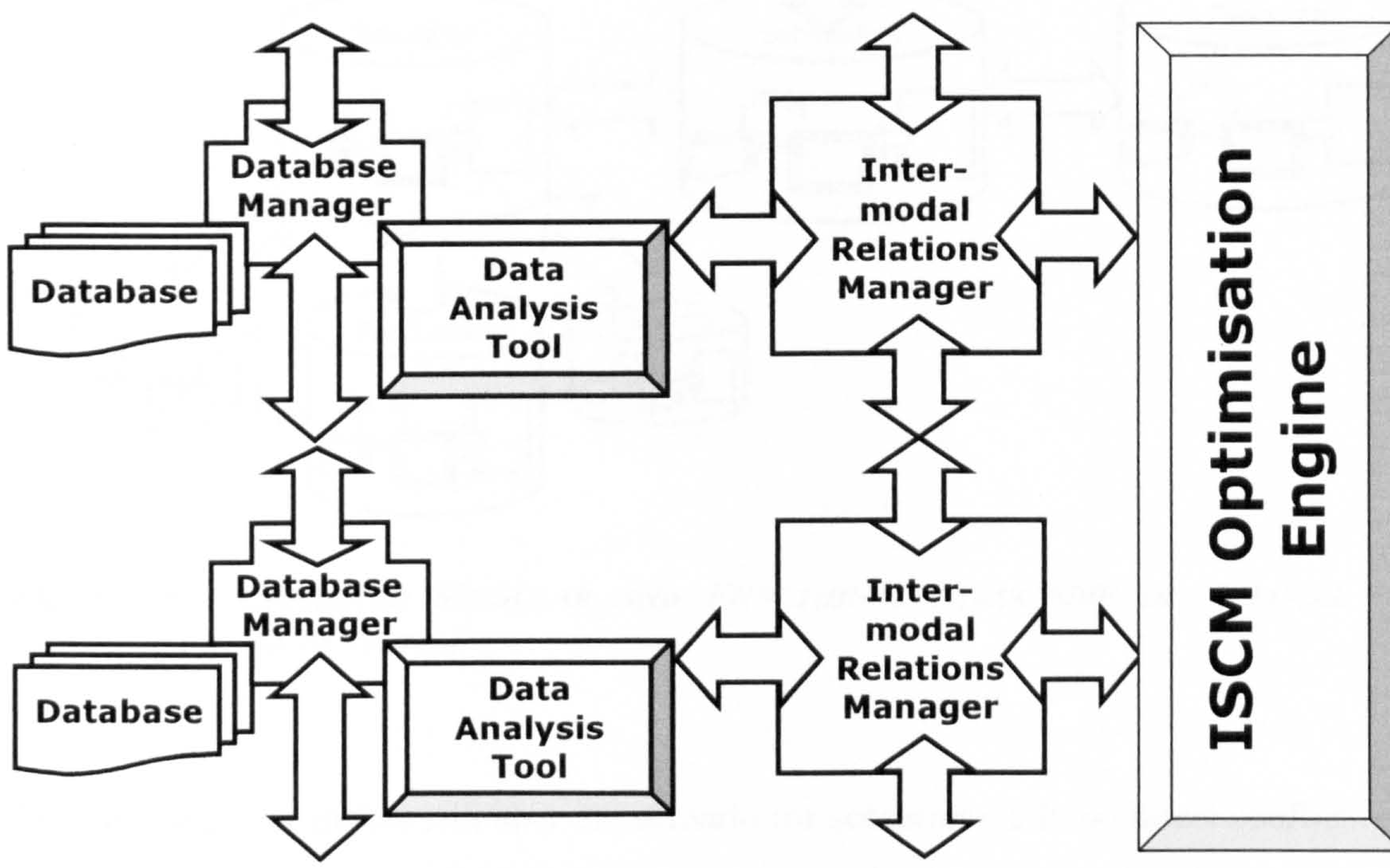

Figure 7.3. INTERACTION BETWEEN ISCM MODULES

Figure 7.4 depicts the structure of a local ICSM system, taking into consideration the inter-modular relationships and the structure of the modules. The number and types of modules that each module connects to will vary depending on the specific industry and needs of the company. However, the links between the modules will always be on both transactional and strategic level, as described above. This ensures the integrity of both the data and the optimisation process throughout the entire ISCM system.

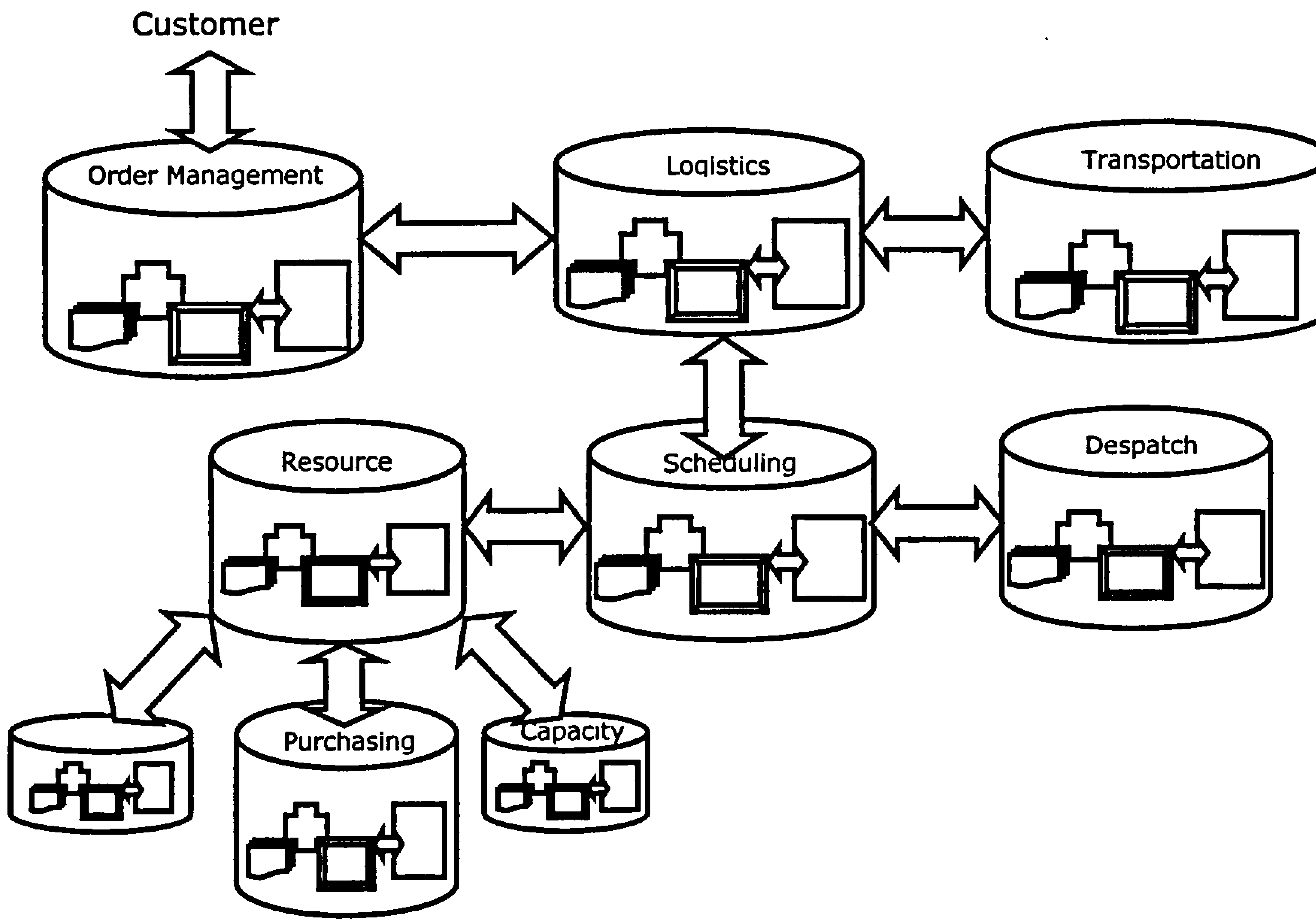

Figure 7.4. ***COMBINED MODULAR AND FUNCTIONAL STRUCTURE OF A LOCAL ISCM SYSTEM***

Once the Manager makes sure that the scenario (or scenarios) is in no direct conflict with the directly related module's principles, it passes the decision (or decisions) onto the ISCM optimisation engine (Figure 7.5.). At this point, the ISCM Optimisation Engine will put together the decisions from all the modules of the local structures throughout the entire supply chain and will achieve an optimal decision for the entire ISCM system. The optimised decision or schedule will be passed back to the modules of the local structures, which will enforce the decision on a local level.

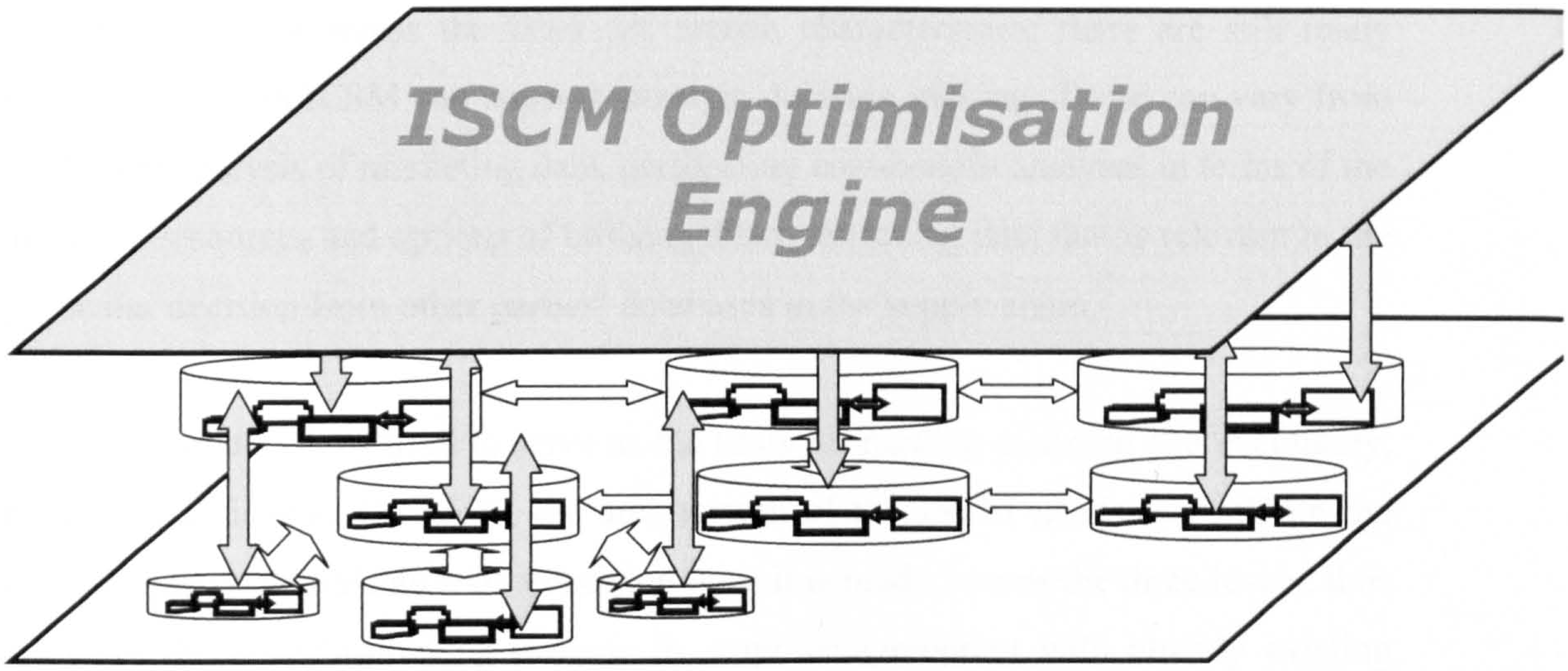

Figure 7.5. *LAYERED ARCHITECTURE OF AN ISCM SYSTEM*

7.2.5 ENSURING THAT THE ICSM TOOL ASSISTS AT ALL LEVELS OF DECISION MAKING - STRATEGIC, PLANNING AND EXECUTION

For an ICSM tool to satisfy all the requirements identified in the previous chapters, it is mandatory to address the needs of decision making at all levels: strategic, planning and execution. There are numerous existing SCM systems that enable the decision making at execution level, a number of existing systems also enable the planning level of decision-making. However, the greatest challenge to an ISCM system will be to provide it with strategic decision-making functionality.

For a system to be efficient at all levels, the author believes that all the levels need to be distinguished precisely and their needs addressed individually. This is necessary to enable the system to set precise cut-off points in the decision-making process, which will be different at all three levels. However, this should not compromise the integrity of the system and the simultaneity of making decisions at all levels.

The first level, where decisions need to be made, is the strategic level. Like all strategic decision-making processes, this level requires detailed knowledge of the resources available to the supply chain, its environment (e.g. competing supply chains, government regulations), the particular market dynamics, the trends in technology development, etc. Decisions also require a lot of creativity, imagination and experience. Whereas the latter are human characteristics, there are still many ways in which an ICSM can support strategic decision making. These can vary from intelligent analysis of marketing data, performing cost-benefit analyses in terms of the available resources and options of utilising them, retrieving data that is relevant to the particular decision from other parties' databases in the supply chain.

The strategic decisions need to serve as the basis for making planning and eventually, execution decisions. Therefore, the architecture of the ISCM needs to facilitate the free flowing communication of a decision once it is made, across the three levels, thus allowing the decision-making process to work in agreement with already existing strategies / plans / schedules and also to update them according to new occurrences in the environment and marketplace.

The communication flow needs to be two-directional. Whereas the initiation of the business direction needs to be at strategic level and enforced down through planning to execution, the decisions at strategic level need information input and feedback from the execution and planning levels. This is illustrated in Figure 7.6.

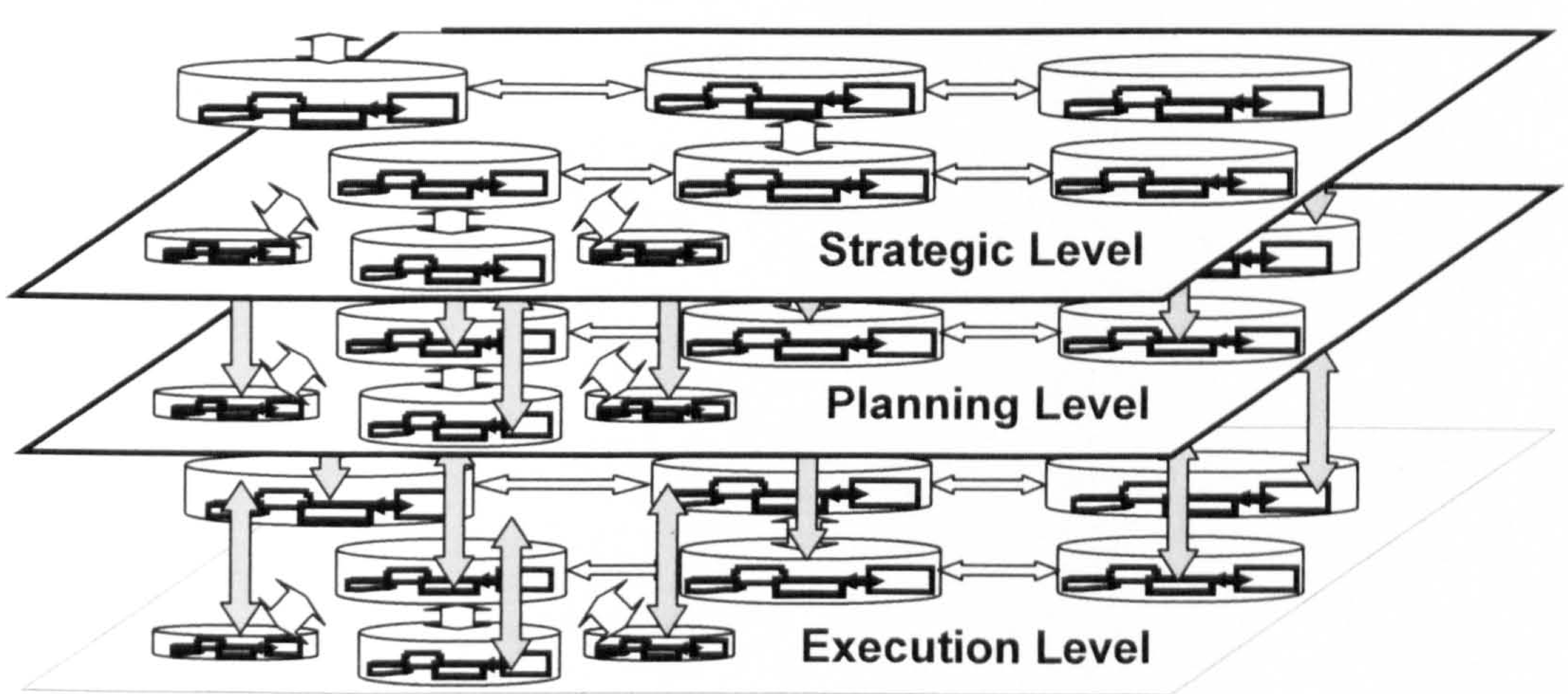

Figure 7.6. *COMMUNICATION FLOWS AMONG THE LEVELS OF DECISION MAKING*

7.3 CONCLUSIONS

The chapter describes the development of a model of an improved supply chain management (ISCM) tool that had the purpose to address all the inadequacies of the existing tools. The structure of the system, as well as the various types of interactions among its modules and levels of decision making were explained and further research projects were recommended that could build on the findings and achievements of the current research.

CHAPTER 8 – CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER WORK

The area of supply chain management has been subject to considerable research in the past few years. The knowledge base in this scientific field has undergone many changes during the duration of this research project. However, the subject is too wide and challenging for it to be fully explored. The author believes that her best endeavours to set and achieve original research objectives have contributed to that vast array of knowledge. It has also resulted in identifying a number of areas that need further research and some issues within the current research that need to be explored and developed further. This chapter discusses and summarises the findings of the research, makes the case for a contribution to knowledge, and concludes with suggestions for future research.

8.1 MEETING RESEARCH OBJECTIVES

The achievement of the research objectives, as defined at the outset of the research project, are discussed in this section. It attempts to answer the research questions and explains why it was impossible to provide a definitive answer to those not answered to the researcher's satisfaction.

8.1.1 DISCUSSION

The thesis started off with a definition of the supply chain and of supply chain management for the purposes of the research. The literature review (Chapter 2) found out that most current SCM systems have been implemented in a fragmented way and often operated independently from one another. This piecemeal approach has failed to provide the integrated overview of the whole supply chain emphasised by the definitions. The research regards SCM as a process covering both planning and execution of the supply chain, where a supply chain encompasses all the entities involved in bringing the desired product or service to the customer, starting from the very beginning, where raw materials are obtained, and extending as far as after-sales services and return logistics. Most systems in use do not provide this integrated approach to decision support and the reliance is on enterprise wide transaction process systems.

Objective 1 - To review the literature to establish current approaches to supply chain planning and execution

Chapter 1 defined the first objective of the research as to find out what tools and methods are currently available for supply chain management and how effective they are. The literature review (Chapter 2) showed that current SCM tools typically attempt to solve localised problems in the supply chain and that they are not capable of solving the problems of an integrated supply chain, which functions as an entity. Optimisation is local, rather than across the entire supply chain. The literature review also helped clarify what kinds of tools and methods would be useful to look into for the purposes of achieving the research objectives and therefore contributed to the research methodology development (Chapter 3). The focus of the rest of the research was on studying available software tools as they were, in SCM experts' opinion, seen to be the way forward to managing the complex supply chains of the future. Building upon advanced communication tools such as the Internet, it would no longer be possible to manage the supply chain without the help of and input from a powerful software system.

Objective 2 - To survey SCM software vendors to identify what commercially available tools and methods for supply chain planning and execution are in the market and their key features

The second objective of the research was to identify activities and functions that are necessary to provide 'improved' supply chain management, and to establish the requirements for improving the way those activities are carried out in practice. The literature review (Chapter 2) identified that the challenge that stands for current research and development in the area of tools and methods for SCM is to develop tools and methods, which:

1) optimise the functioning of the supply chain, and

2) provide the functionality of a strategic decision-making tool that accounts for the company's future plans for supply chain development and enables the user to simulate different scenarios.

The analysis of the interviews with supply chain management experts (Chapter 5) helped develop that understanding further. While this research method proved to consume more time than was initially planned and was available, especially when it came to validating the results and getting the experts' approval on the final conclusions, the author believes that the results from the expert interviews are still an important input into the research. With hindsight, the author would have applied more advanced and structured interviewing techniques, such as a Delphi study, in order to achieve more definitive results and stronger conclusions from the expert interviews. However, the outcomes from the survey still provide the outline of a picture that places the rest of the research in a more precisely defined context. The interviews suggested that the way that experts see the future structure of world-class supply chains is that they will consist of a number of organisations, each with a role to play in providing the solution the customer is seeking, and all of them committed to a common set of goals and objectives. The future supply chain will be based on close and deep collaboration with customers, suppliers and service providers. The set of information on which its management is going to be based, will have to be commonly shared throughout the entire supply chain and be consistent and visible across the entire supply chain. It should be appreciated that this idea is utopian to a certain degree, and that it is not likely that such supply chain management approaches will take shape in the foreseeable future.

Another characteristic of the information flowing across the supply chain is that it will need be very timely, if not truly real-time, to enable the seamless integration between planning and execution systems. The improved supply chain will enable companies to make future commitments with online availability, configuration and pricing that takes account of all parties along the chain. All types of management decisions will be based on automated and intelligent exception management. Companies will be able to manage their profits whilst ensuring continuity of supply and optimisation of the benefits for all companies participating in the supply chain. Although the tendency is for companies to implement improved systems for data management and modern technologies are making data flows closer and closer to being real-time operation these days, true real-timeliness of the data flows up and down the entire supply chain are still not a reality and the author appreciates the fact that this is another hurdle to be overcome on the way to achieving improved SCM.

The survey by questionnaire demonstrated the many various areas, in which SCM software vendors have developed their software solutions. The author believes that those areas have been developed either in response to actual customer requirements or as a result of identifying a gap in already existing solutions that fail to address specific areas of SCM. In order to achieve the functionality, which SCM requires, SCM software systems need to satisfy all those functional requirements, for example: be able to provide item-level demand planning, sales forecasting and demand management, replenishment and supply planning, collaborative planning, forecasting and replenishment with key trading partners for critical product categories, supplier relationship management, order management and fulfilment, real-time dynamic scheduling of materials and production, transportation planning, scheduling and management in collaboration with third parties, and network design and optimisation. This conclusion came out from the the survey by questionnaire and was confirmed by some experts' statements during the expert interviews. The case studies also had an input into reaching some of the above conclusions, by demonstrating that the improved SCM system needs to assist supply planning and supplier relationship management (case study 1), to keep strategic planning and scheduling dynamically aligned with external factors such as changes in the marketplace and the global economy (case study 2), as well as to provide an overview of the immediate supply chain of the company in order to enhance visibility and highlight inefficiencies (case study 3).

Objective 3 - To categorise current approaches to supply chain management currently used and establish a current practice supply chain management model

The third objective of the research was to study existing SCM software tools with the objective to find out whether they provide adequate functionality to satisfy the demands of 'improved' SCM. The literature review (Chapter 2) suggested that, while many existing software packages are claimed to optimise and integrate the supply chain, the existing SCM software tools are mainly transaction processing systems.

Many software packages do well in the area of integrating with other supply chain members' existing systems to exchange information but they rarely go further towards real integration. They offer no solution with respect to decision support to meet the need to optimise the structure, planning and construction of the supply chain on the strategic level, neither do they help to optimise the running of the supply chain on the tactical level.

The survey by questionnaire (Chapter 4) helped expand the above observations and gain a deeper insight into the SCM software market. It became clear that software vendors still think of supply chain management software as an execution system that is designed to complete transactions and enable the smooth transition of information around the enterprise but they provide only limited decision support. The strategic planning ability, which is a necessity for ISCM, is a feature that is overlooked by the majority of software development companies and is certainly lacking in the functionality of the reviewed software solutions.

Functional integration is a serious issue with all the reviewed software systems. Enterprise-wide optimisation is a challenge that is still to be overcome in order to achieve the functionality that is necessary to manage efficiently the entire supply chain and not only parts of it. Areas such as inventory and production planning are relatively well developed and popular in most of the systems promoted as SCM. However, warehousing and especially transportation management systems are rarely integrated in a SCM suite.

In the conclusions from Chapter 4, the survey by questionnaire demonstrated that no advanced SCM software system currently exists on the market. The two most important requirements for a system, in order for it to enable SCM, are not met by any existing software system – no system is a true optimisation tool and none of the systems recognises the need to manage all the functions and entities within the supply chain in a synchronised manner so that the information can flow smoothly and decisions can be made in an informed way, taking into account all significant factors, rather than function-specific data. Despite the author's best endeavours to review and survey as many software packages as possible, it should be acknowledged that the above conclusions are based on a sample and not on all of the existing SCM solutions.

That is why it was necessary that the conclusions be tested and verified by means of other research methods, such as the expert interviews and, to some extent, the three case studies.

The interviews with experts in the area of SCM (Chapter 5) confirmed indeed that the market for SCM tools is far from offering an integrated SCM suite encompassing both planning and execution. In addition, experts testified that there is a lack of complete functionality even within the SCE sector, as the vendors have yet to offer a fully functional execution suite spanning inventory, warehouse and transportation management. SCME reported that most of the point solutions focus on processing execution data and fail to recognise the need of further and careful analysis of other factors that contribute to effective decision-making. The major problem that exists with currently available SCM software applications is the issue of integration – both with existing software systems, and integration between the various SCM functions.

Objective 4 - To adopt a case study approach to identify the requirements for improved supply chain planning and execution

Under objective 4, three case studies were carried out with the aim to identify requirements for improved supply chain planning and execution and to design and implement solutions to problems in the area of SCM.

Case study 1 reviewed the extensive supplier base of an SME and identified that management lacks the tools and methods to effectively manage its supplier interface. Data was available but rarely used for analysis and assessment of supplier performance because of the time required to retrieve this. Having identified the need of a tool to process the available data and represent it in a user-friendly way, the author designed a software application to address those needs. The resulting deliverable and the conclusions from case study one contributed to the achievement of Objective 4 in identifying the requirement from ISCM solutions to assist in supplier relationship management and also suggested a novel way of satisfying that requirement.

Case study 2 underwent a number of changes in its design and objectives throughout its course. After a promising start, the case study company's market changed dramatically so that the firm was in a state of flux and the management had to change its strategic course during the case study. This reflected on the commitment of staff to the case study. Despite the author's greatest efforts in keeping the focus of the case study on achieving the research objectives, the initially planned improvement to supply chain management practices of the company was not achieved. Nevertheless, the case study, contributed to the conclusions of the research by revealing one more company that does not use SCM tools and methods to facilitate operations and decision-making. It also suggested that the lack of alignment of strategic planning with the business environment of the company was the main reason for the problems that the business experienced. The latter observation contributed to defining the requirement that an ISCM tool needs to account for factors that are external to not only the company but its entire supply chain, such as emerging markets and the resulting new business opportunities, as well as emerging competition on a world-wide basis.

Case study 3 dealt with a large multi-national company and the issues arising in aligning the business strategies of all parts within the company. The author observed that the company did not have a uniform SCM software strategy and that the locally used SCM solutions did not communicate with each other and, therefore, failed to achieve any level of integration throughout the supply chain. Having discovered that, the author designed an efficient tool to represent the supply chain of the company in a "diagrametric" way – the **diagrametric supply chain map**. This novel tool represents a map of the supply chain of the company while also including diagrams and other visual tools (such as bar and pie charts) in order to show an at-a-glance representation of major SCM metrics (such as material costs, manufacturing costs, transportation costs, etc). The diagrametric supply chain map was designed by the author as a starting point for SCM tool integration – a suggested "meeting point" for the output of all local SCM systems, where data/information is represented in a systematic, uniform format for the purposes of supply chain management. The positive feedback from the management of the company after putting the map into use is a proof that integrating the supply chain by integrating the tools for SCM is an important requirement from an ISCM.

The major requirements from supply chain management software that were identified during the case studies confirm what had already been identified during the expert interviews. An advanced supply chain management tool needs to offer functionality in all areas of the supply chain in order to help make coherent decisions, relevant to the problems of all operations within the supply chain. ISCM tools need to provide insight into both the big picture and the smallest detail. That is only possible if the tool uses up-to-date, real-time data about all the separate parts of the supply chain.

Finally, the three case studies which were carried out during the research, suggested that the currently available software tools on the market are not popular with the majority of companies – that is true not only of small companies, but medium-sized and large enterprises as well. Off-the-shelf supply chain management solutions are rarely an adequate fit to companies' needs and requirements. Very often companies work around the disadvantages of the tool that has been selected and implemented, putting up with its lack of functionality and scope. Bespoke solutions prove to be better received as they fit the requirements more successfully – both in terms of functionality and ability to integrate the supply chain, and cost.

Objective 5 - To produce an outline requirements specification for improved supply chain planning and execution based on the current practice supply chain management model

The research served as a prerequisite for recommending a specification of an ISCM tool. Each part of the research contributed to either a different part of the formulation of the ISCM tool, or reiterated the need to address a specific issue or area of SCM. The findings from the survey by questionnaire helped form the skeleton of the ISCM – that is, identify the main areas of SCM, which can be aided by the application of a SCM system. Those areas are: order management, logistics, transportation, scheduling, resources, and despatch. The survey also helped reaffirm the lack of a comprehensive tool with both integration and optimisation functionality on the marked and therefore, gave the author the confidence that developing the model would contribute to the current state of knowledge. The interviews with SCME confirmed the conclusions from the survey by questionnaire and gave some further ideas about ways, in which various parts of the ISCM would enhance decision making. The interviews were an important prerequisite for the part of the case studies where the researcher developed solutions to specific problems that she observed at the case study companies. Another important contribution of the interviews to the development of the model was the requirement that the ISCM would work with real-time data. The case studies tested the skeleton and principles that were defined as a result of the previously applied research methods. Whereas the model could not be formed by means of case studies alone, they were an important field for testing concepts and ideas that were formed at the previous stages of the research. The case studies helped the author test and prove a number of statements about the developed model, such as the fact that comprehensive functionality in not sufficient for a tool to help SCM efficiently – it also needs to provide integration between those functions (case study 3). Case study 3 also demonstrated that optimisation is dependent on that integration and the supply chain cannot be optimised if the various functions and data flows are not integrated. Case study 2 demonstrated the credibility of the statement that the SCM tool needs to enhance not only the transactions and day-to-day operational management but also take into account the overall business strategy and aid the process of formulating that. Case study 1 demonstrated the importance of supplier relationship management and how a software tool can enhance that considerably.

As a result of the above, the research project has met its ultimate objective by suggesting ways of improving existing SCM software and by outlining a specification of a new ISCM tool. The conclusion is that an improved SCM tool needs to offer functionality in all areas of the supply chain in order to help make coherent decisions that are relevant to the problems of all operations within the supply chain. The architecture and functional structure of the tool were also proposed as a part of the specification of the tool. The main modules of a complete ICSM system were identified and the interactions between them, as well as with the optimisation engine of the system, were described.

The author recognises that the model given is an 'idealised' system and the fact that the specification will undergo modifications and improvements as it is being developed and implemented. However, her strong belief is that the research has contributed to setting the basis for the application of a revolutionary supply chain management tool and has focused the attention of future researchers on the importance of addressing the needs of the supply chain as a whole through a series of interacting modules, rather than focusing solely on the optimisation of parts of it.

8.1.2 RESEARCH FINDINGS

In summary, the body of the research findings is as follows:

- supply chain management needs to address the decision-making process at all levels – strategic, operational, execution;

- supply chain management needs to base its decisions around the optimum for the entire supply chain, rather than a single organisation within it;

- existing tools and methods generally fail to satisfy the above requirements;

- comprehensive research in supply chain management tools and methods has not been carried out to achieve a detailed classification and documentation of existing tools and methods;

- three case study companies of various sizes and industries benefited from the implementation of tools to manage a local area of their supply chains. Although the benefits were limited to a single company and/or a single function, they suggested that today's companies do not make the most of existing solutions and the implementation of an ISCM would be of an even greater benefit;

8.2 RESEARCH CONTRIBUTIONS TO KNOWLEDGE

This research has reviewed the area of supply chain management tools and methods. As a part of this, it has come up with the conclusions that existing software systems have not been classified and tested against the criteria of a true supply chain management system. The contribution of this research in that area has been in carrying out a comprehensive literature survey on the subject. As a part of that, the research has contributed a conclusion as to what SCM involves and what a comprehensive SCM system is. The literature survey also resulted in the development of a SCM matrix (Appendix 4.1A and Figure 4.1.) to help assess the match of existing SCM solutions against a comprehensive SCM solution. The survey of present SCM software solutions also came up with a statistical analysis of what typical SCM applications include at the present moment in time. The survey of existing software tools resulted in the conclusion that a comprehensive SCM solution currently does not exist. That conclusion was supported by the SCM expert interviews. The survey, based on those interviews, is another contribution to knowledge as it helps update the existing literature on SCM with the latest trends in the concept of SCM and the tools and techniques used in the area.

The three case studies contributed, each in its own way, to achieving the research objectives. Case study one presented the opportunity to study the needs of, to design and implement a supplier relationship management application. As a part of that exercise a novel tool for supplier classification was developed, that was based on the needs of the particular company but is also applicable in other companies and industries. The entire tool, which is based on a commercially available Microsoft database application, can be implemented in other companies with minor customisations required. Case study two demonstrated the importance of strategic analysis in building a supply chain model. Although the full benefits of the simulation were not reaped by the company, because of the difficulties it was facing at the time, the case study demonstrated the potential benefits that could be derived from carefully planning and scheduling the supply chain activities. A full mapping of the manufacturing operations of the company was also carried out and documented. Case study three resulted in the researcher designing and implementing a new comprehensive supply chain mapping tool. The case study company is still using the tool at present, although the labour-intensive updating of the tool suggests that a software-based, automatically updated supply chain map will be of greatest benefit.

The specification of an improved SCM tool in Chapter 7 contributed a conceptual model that can be used as a basis for future SCM software developments. The author believes that it is a comprehensive model of an advanced SCM application in that it indicates basic and advanced structures, as well as interaction paths and data flows throughout the entire tool.

8.3 FUTURE RESEARCH

During this research, the author has faced a number of challenges and has identified gaps in the existing knowledge base that indicated the need of further research into a few areas. The research has also come up with a model that would greatly benefit from future development. That is why the author feels it necessary to suggest the following subjects for future research:

1. Matters that need further research concerning the specification of an ISCM:
   - obstacles to implementing an ICSM based on real-time data;
   - deciding on an acceptable compromise between conflicting objectives in achieving the optimal decision for all the members of the supply chain;
   - factors that need to be considered in deciding how to set the point where flexible plans become fixed for the purposes of decision-making;
   - factors that need to be considered when deciding where and how much of the data to store within a system for the purposes of decision-making. Central repository versus localised databases;
   - selecting single or multiple (and how many) scenarios that satisfy the objectives of a module to be passed on for consideration by other modules and the optimisation engine;

2. Software development of an ISCM – the software to support the functionality, as described above, needs to be developed. This in itself is a huge task and needs to be undertaken by a team with various types of expertise. Because of the extent of the challenge, the software development needs to be undertaken either by a large software development company or as a series of research projects.

3. Developing a software application that automatically retrieves data from management systems and updates the diagrametric supply chain map. This task is not as demanding as the previous one and can be fulfilled as a part of a single

research project. The required skills are in the area of software programming and enterprise management system implementation and integration.

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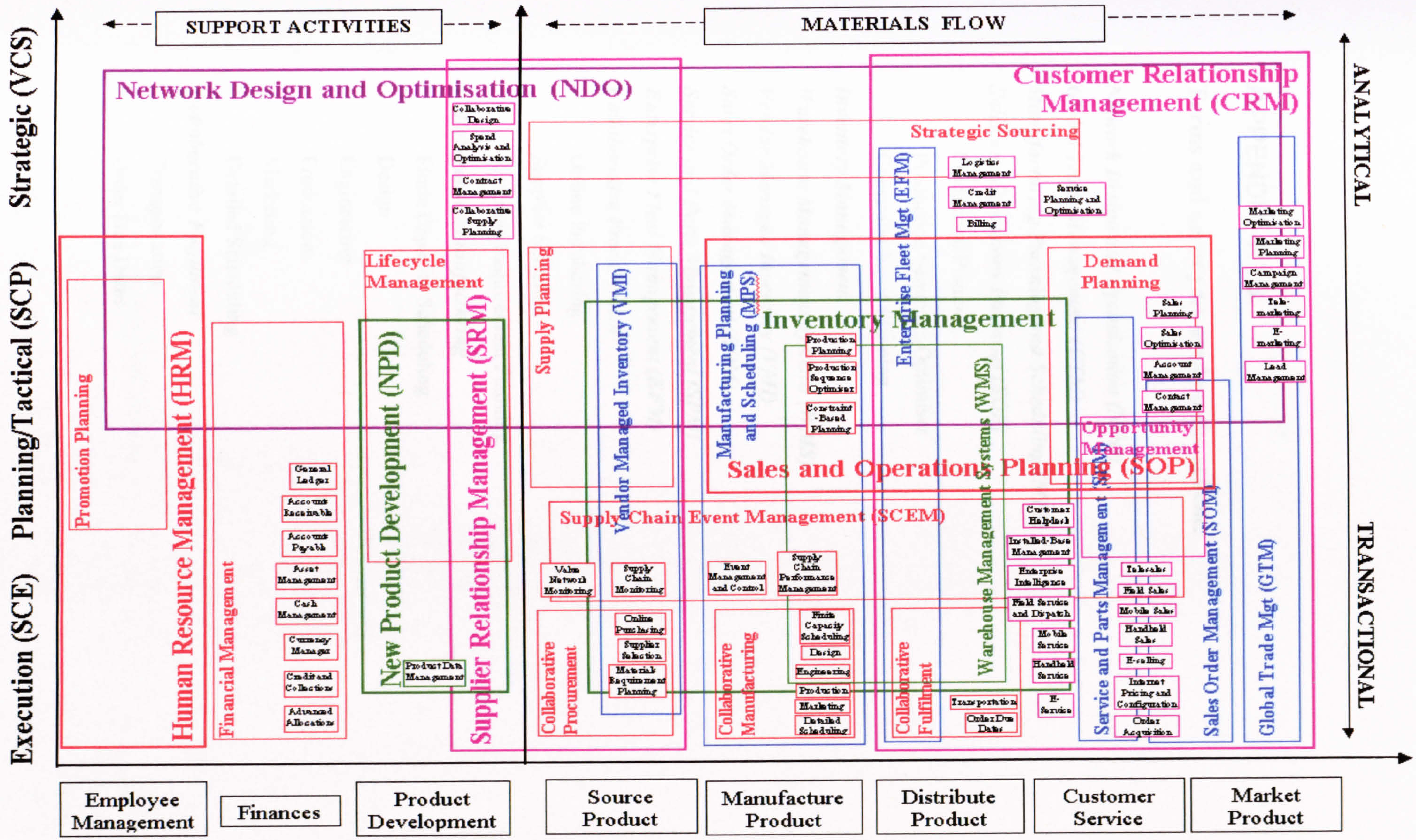
APPENDICES

APPENDIX 4.1A

Structure of an advanced SCM software tool



SUPPORT ACTIVITIES
MATERIALS FLOW
Strategic (VCS)
Planning/Tactical (SCP)
Execution (SCE)
ANALYTICAL
TRANSACTIONAL
Network Design and Optimisation (NDO)
Customer Relationship Management (CRM)
Strategic Sourcing
Human Resource Management (HRM)
Promotion Planning
Financial Management
General Ledger
Account Receivable
Accounts Payable
Asset Management
Cash Management
Currency Manager
Credit and Collections
Advanced Allocations
Lifecycle Management
New Product Development (NPD)
Product Data Management
Supplier Relationship Management (SRM)
Collaborative Design
Spend Analysis and Optimisation
Contract Management
Collaborative Supply Planning
Supply Planning
Vendor Managed Inventory (VMI)
Collaborative Procurement
Value Network Monitoring
Supply Chain Monitoring
Online Purchasing
Supplier Selection
Materials Requirement Planning
Supply Chain Event Management (SCEM)
Manufacturing Planning and Scheduling (MPS)
Inventory Management
Production Planning
Production Sequence Optimiser
Constraint-Based Planning
Event Management and Control
Supply Chain Performance Management
Collaborative Manufacturing
Finite Capacity Scheduling
Design
Engineering
Production
Marketing
Detailed Scheduling
Sales and Operations Planning (SOP)
Enterprise Fleet Mgt (EFM)
Logistics Management
Credit Management
Billing
Service Planning and Optimisation
Warehouse Management Systems (WMS)
Collaborative Fulfilment
Transportation
Order Due Dates
Demand Planning
Sales Planning
Sales Optimisation
Account Management
Contact Management
Opportunity Management
Customer Helpdesk
Installed-Base Management
Enterprise Intelligence
Field Service and Dispatch
Mobile Service
Handheld Service
E-Service
Service and Parts Management (SPM)
Telesales
Field Sales
Mobile Sales
Handheld Sales
E-selling
Internet Pricing and Configuration
Order Acquisition
Sales Order Management (SOM)
Global Trade Mgt (GTM)
Marketing Optimisation
Marketing Planning
Campaign Management
Tele-marketing
E-marketing
Lead Management
Employee Management
Finances
Product Development
Source Product
Manufacture Product
Distribute Product
Customer Service
Market Product

APPENDIX 4.1B

Terms and acronyms used on the scheme

Network Design and Optimisation (NDO)

Global Trade Management (GTM)

Manufacturing Planning and Scheduling (MPS)

Sales and Operations Planning (SOP)

- Production Planning
- Production Sequence Optimiser
- Constraint-based Planning

Inventory Management

Warehouse Management Systems (WMS)

Vendor Managed Inventory (VMI)

Sales Order Management (SOM)

Service and Parts Management (SPM)

Enterprise Fleet Management (EFM)

Collaborative Procurement

- Online Purchasing
- Supplier Selection
- Materials Requirement Planning

Collaborative Manufacturing

- Finite Capacity Scheduling
- Design
- Engineering
- Production
- Marketing
- Detailed Scheduling

Collaborative Fulfilment

- Transportation
- Order Due Dates

SEM (supply chain event management)

- Value Network Monitoring
- Supply Chain Monitoring
- Event Management and Control
- Supply Chain Performance Management

Demand planning

Supply planning

Promotion planning

Strategic sourcing

CRM (Customer Relationship Management)

- Logistics Management
- Credit Management
- Billing
- Service Planning and Optimisation
- Customer helpdesk
- Installed-base Management
- Enterprise Intelligence
- Field Service and Dispatch
- Mobile Service
- Handheld Service
- E-service
- Sales Planning
- Sales Optimisation
- Account Management
- Contact Management
- Telesales
- Field Sales
- Mobile Sales
- Handheld Sales
- E-selling
- Internet Pricing and Configuration

Order Acquisition

Marketing Optimisation

Marketing Planning

Campaign Management

Telemarketing

E-marketing

Lead Management

Opportunity Management

SRM (supplier relationship management)

Collaborative Design

Spend Analysis and Optimisation

Contract Management

Collaborative Supply Planning

HRM (human resource management)

Financial Management

General Ledger

Accounts Receivable

Accounts Payable

Asset Management

Cash Management

Currency Manager

Credit and Collections

Advanced Allocations

Lifecycle Management

New Product Development (NPD)

Product Data Management

APPENDIX 4.2

SCM Survey Questionnaire

SURVEY OF
SUPPLY CHAIN MANAGEMENT SOFTWARE

APS SIG - Institute of Operations Management, UK
University of Huddersfield, UK

INTRODUCTION

BACKGROUND

Supply Chain Management software applications provide real-time analytical systems that manage the flow of product and information throughout the supply chain network of trading partners and customers. The chain includes many different functions, such as sourcing, production planning, warehousing, transportation, demand forecasting, and customer service. Supply chain management applications empower managers to streamline operations and better understand their strategic decisions. The general idea in literature and publications is that the present Supply Chain Management solution market is fragmented along these functional lines with most vendors selling into specific spaces. The trend, however, is to consolidate these disparate functions into a comprehensive supply chain planning suite.

THE SURVEY

The present survey is a part of a research project reviewing Supply Chain Tools and Methods, undertaken jointly by the University of Huddersfield and The Institute of Operations Management Advanced Planning and Scheduling Special Interest Group (APS SIG). The aim of the project is to find out what tools and methods are currently available for supply chain management; how effective they are; to identify the requirements for improved management of a supply chain and to identify ways to improve the inefficiencies in current supply chain management.

The aim of the present survey in the project is to identify and collect general information about the solutions currently available on the market which support supply chain management. The second stage of the survey will involve a detailed questionnaire which will help identify the current state of the development of supply chain software and see to what extent the consolidation between the functional lines has already been achieved.

HOW TO COMPLETE THE QUESTIONNAIRE

Please note that the information you provide in the questionnaire will be treated as strictly confidential and will not be made available to any third parties.

Please indicate the appropriate answer for all questions. If the question is not relevant to your software, please feel free to comment on why it is not relevant

If you need explanation or are not sure about the meaning of any of the terms mentioned in the questionnaire, please do not hesitate to contact us. We will be more than happy to answer any questions you might have.

Please feel free to add any comments you might have. For example, it is very important that you tell us about any additional modules/features to those listed in the questionnaire.

Please return this questionnaire completed to:

Ivelina Ivanova
School of Engineering

University of Huddersfield
Queensgate
Huddersfield HD1 3DH
United Kingdom

For any questions or comments regarding the questionnaire, please send an e-mail message to i.ivanova@hud.ac.uk or call either +44 (0)1484 473088 (during office hours), or +44 (0)77528 72332 (Miss Ivelina Ivanova).

Thank you very much for your assistance!

PART I: GENERAL INFORMATION ABOUT THE RESPONDENT, THE COMPANY AND THE SOFTWARE

I.1. RESPONDENT'S CONTACT INFORMATION:

I.1.1 - Name: (Mr, Mrs, Ms, Miss, Dr.) __________

I.1.2 - Job position: ____________________________

I.1.3 - Phone: area code ______ local number _______________

I.1.4 - Fax: area code ______ local number

I.1.5 - E-mail: ____

I.2. COMPANY INFORMATION:

I.2.1 - Company name: ____

I.2.2 - Web address: ____

I.2.3 - Mailing address: street ____

city/town______________________ postcode__________ country ___________

I.2.4 - Phone: area code ______ local number ____________________

I.2.5 - Fax: area code ______ local number ____________________

I.2.6 - General e-mail: ____

I.3. GENERAL INFORMATION OF THE MAIN SUPPLY CHAIN MANAGEMENT TOOL THE COMPANY OFFERS:

I.3.1 - Product name: ____

I.3.2 - Typical user profile:

Annual turnover: minimum: £ ________________ maximum: £ ____________

Number of users: minimum: ________________ maximum: ____________

Targeted industries for the product (e.g. automotive, food processing, etc):

____

Type of company (please tick all that apply):

☐ Manufacturer ☐ Assembler ☐ Distributor
☐ Retailer ☐ Wholesaler ☐ Home Delivery
☐ Warehousing ☐ Transportation ☐ Packaging

Other: ____

I.3.3 – It would be useful if you are able to list five current users of the system. They will not be approached without contacting you first.

	Company name	Contact person	Location	Phone	E-mail
1					
2					
3					
4					
5					

PART II: SOFTWARE FEATURES

In the sections below, we ask you to provide more detailed information about the solutions your product offers in each of the areas of the value chain.

II. 1. TYPE OF THE SYSTEM

Which of the following best describes the system you offer? (please tick all that apply)

☐ Enterprise Resource Planning (ERP) (a transaction based system which works at the highest corporate level providing a planning and scheduling backbone for general administrative functions from financials to customer orders)

☐ Supply Chain Planning (SCP) (helps plan and design the supply chain at the strategic level – aids general long-term decisions regarding the structure of the supply chain)

☐ Supply Chain Execution (SCE) (helps make decisions regarding the operation of the supply chain and the execution of daily activities, the structure of the supply chain is considered as fixed in making Supply Chain Execution Decisions)

☐ Advanced Planning and Scheduling (APS) (creates production plans and schedules in manufacturing plant. Use constraints and business rules to optimise the schedule)

☐ Order Management Systems (OMS) (validates and prioritises customer orders for the next three software classes that get the work done)

☐ Manufacturing Execution Systems (MES) (receives orders and dynamically manages resources on the shop floor from equipment and labour to inventory needed to fill those orders)

☐ Warehouse Management Systems (WMS) (directs and controls in real time all activities and resources within the warehouse)

☐ Transportation Management Systems (TMS) (focuses on controlling costs and managing inbound, outbound, and intra-company movement of goods)

II.2. LEVEL OF DEVELOPMENT OF THE SYSTEM

For each of the items you ticked in the question above, please indicate the level to which it can be ascribed to the system:

Feature	System focus (one tick only)	Has all main functions	Well developed but not full functionality	Only the most basic functions are available	Under development
ERP	☐	☐	☐	☐	☐
SCP	☐	☐	☐	☐	☐
SCE	☐	☐	☐	☐	☐
APS	☐	☐	☐	☐	☐
OMS	☐	☐	☐	☐	☐
MES	☐	☐	☐	☐	☐
WMS	☐	☐	☐	☐	☐
TMS	☐	☐	☐	☐	☐

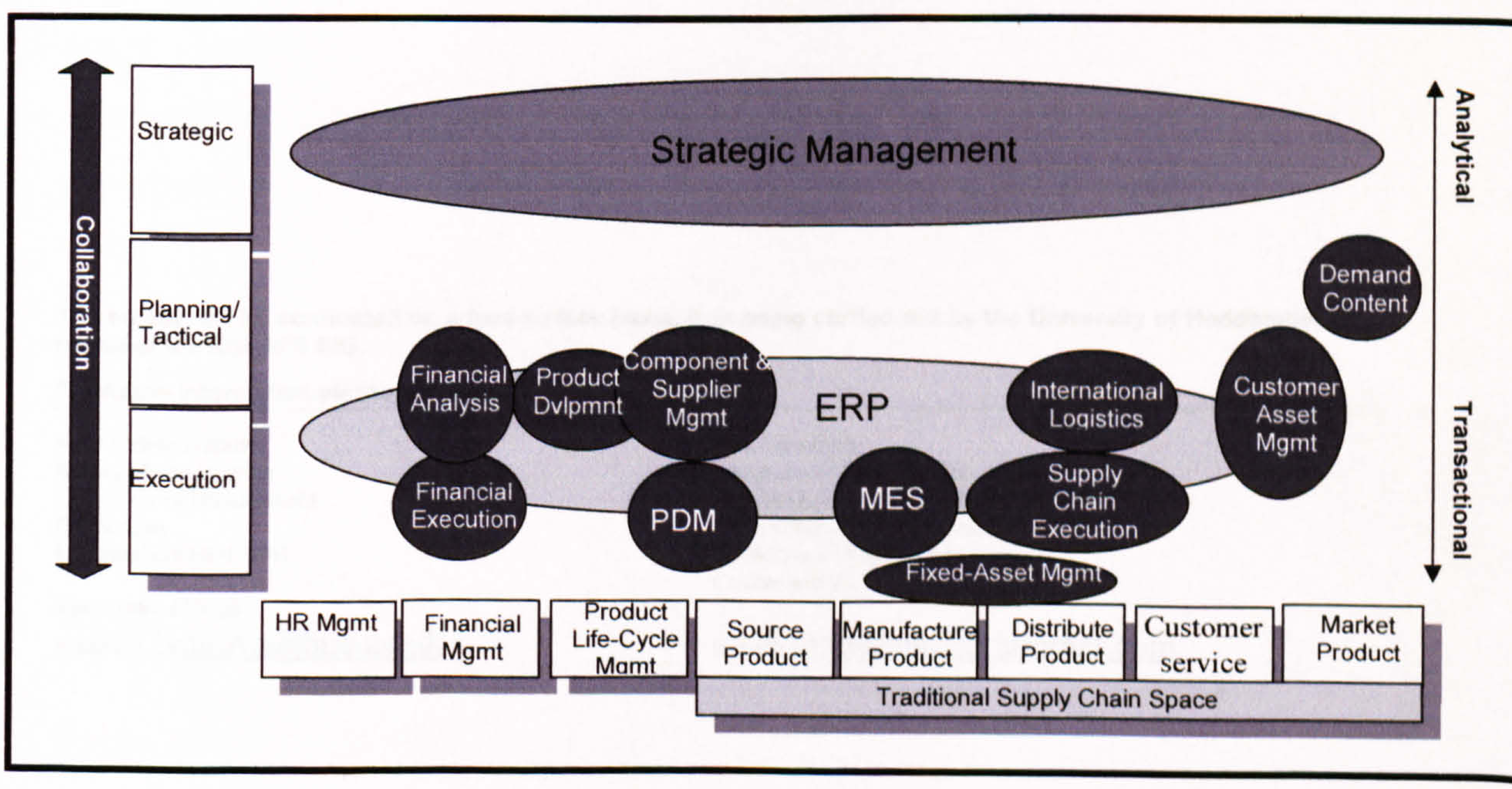
II.3. Modules of the System

Please indicate if the system has the modules listed below

Module	Yes	No	Not sure
II.3.1 - Sales and Logistics			
II.3.1.1 - Remote order entry	☐	☐	☐
II.3.1.2 - Order Management	☐	☐	☐
II.3.1.3 - Product Configurator	☐	☐	☐
II.3.1.4 - Order Promising	☐	☐	☐
II.3.1.5 - Billing	☐	☐	☐
II.3.1.6 - Receivables	☐	☐	☐
II.3.1.7 - Inventory	☐	☐	☐
II.3.2 - Materials Management			
II.3.2.1 - Purchasing	☐	☐	☐
II.3.2.2 - Inventory	☐	☐	☐
II.3.2.3 - Payables	☐	☐	☐
II.3.2.4 - Expenses	☐	☐	☐
II.3.2.5 - Asset Management	☐	☐	☐
II.3.3 - Supply Chain Planning			
II.3.3.1 - Demand Planning	☐	☐	☐
II.3.3.2 - Inventory Planning	☐	☐	☐
II.3.3.3 - Enterprise Planning	☐	☐	☐
II.3.3.4 - Production Planning	☐	☐	☐
II.3.3.5 - Order Promising	☐	☐	☐

II.4. Scope of the System

In the diagram below, please indicate with a circle the position of your system. To help you with that, the position of some of the most popular types of software systems are indicated.



II.5. ADDITIONAL QUESTIONS

II.5.1 - Would you be interested in allowing us to review your software at the second stage of the survey and thus having information about it included in databases, publications, guides and other proceedings of the survey?

Yes☐ **No**☐

II.5.2 - If you answered with "Yes" to the question II.4.1, please tell us the name of the person to contact

II.5.2.1 - Name: (Mr, Mrs, Ms, Miss, Dr.) ____________________________

II.5.2.2 - Job position: ___________________________

II.5.2.3 - Phone: area code ______ local number _______________

II.5.2.4 - Fax: area code ______ local number _______________

II.5.2.5 - E-mail: ____

The survey will be conducted on a face-to-face basis. It is being carried out by the University of Huddersfield on behalf of the IOM APS SIG.

For future information please contact:

Miss Ivelina Ivanova
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Huddersfield HD1 3DH

Tel: 01484 473088
E-mail: i.ivanova@hud.ac.uk

Rod Moulding
Chairman of the APS SIG
The Institute of Operations Management
The University of Warwick Science Park
Sir William Lyons Road
Coventry CV4 7EZ

E-mail: moulding@btinternet.com

APPENDIX 4.3

Software companies included in the first round (201)

Active
Actuate UK Ltd.
Adapta Soutions
American Software (U.K.) Ltd.
Analytical Systems Ltd.
Applix UK
Apriso
AquiTech Ltd
Ardent Software UK
Ariba
Artemis Business Solutions
Ascent
Ascential Software
Aspect Development
AspenTech Limited
ATMS Limited
Aurega Enterprise Solutions
Aurega Integrated Manufacturing
Baan
BEC (UK) Ltd
Belgravium
Blackbird Data Systems
Bluestone
BMC
BroadVision
BT Ignite
Bucks Net Services Ltd.

Business Engine Software
Byford Computer Services Limited
CAPS Logistics Europe
Catalyst International
Chess Logistics Technology Ltd.
Cincom Systems (UK) Limited
Cincom Systems (UK) Limited
Cognos Limited
Commerce One Europe
Computer Associates
Constellar
Control Group Limited
CorVu Plc
CrossWorlds Software
Cube Software Limited
Damgaard Ltd.
Datel (UK) Ltd.
DEDICATEDengines Ltd.
Demand Solutions (Europe) Ltd
Demantra
Descartes Systems Group
Diagonal Computer Services
Dragnet E-Business Ltd
DynaSys UK Ltd
E3 United Kingdom, Ltd
Enigma
Epicor Sotfware Limited
Epiphany (UK) Ltd
Ethitec
EXE Technologies
Exel Computer Systems plc

Extricity, Inc. Europe
FirePond, Inc.
FortyOne
Fourth Shift Corporation
Frontstep (UK) Ltd
FuturMaster
FWL Technologies Limited
Geac Enterprise Solutions
Get Real Systems Limited
Glovia Inc.
Gomark Ltd.
Great Plains
HAHT Software, Inc.
Halstead Software Limited
Honeywell Hi-Spec Solutions
Hyperion
i2 Technologies UK
IBM (UK) Ltd
IBS (International Business Systems)
IFS
ILOG Ltd
Impaq Information Management (UK) Ltd
Infbank International
infor:swan business solutions
Information Engineering
Insight Logistics Ltd
Intellident Ltd
Intentia (UK) Ltd
InterBiz
Intershop (UK) Ltd
IONA Technologies

J.D.Edwards (UK) Ltd
JDA International Ltd
Kewill ERP Inc.
KingswoodMapMechanics
Lawson Software
Level8
Lilly Software Associates Ltd
LIS
LogicLine Ltd
Logility International
Lucent Technologies
Lynx Commercial Systems
M2 Systems Limited
Made2Manage Systems Ltd
Mancos
Manhattan Associates
Manugistics UK Ltd
Mapics
MARC Global Services
MatrixOne
MAX International Ltd
Mazlan Technologies Ltd
McGuffie Brunton Ltd
McHugh Software International
Mercia Software
Metaphorix
Microlise Limited
Microsoft Limited
MicroStrategy Ltd.
Mikrofax Software Ltd
Mincom Services Pty Ltd

Minerva Industrial Systems Plc
MJC2
Morris Material Handling Ltd
MRO Software
Navision
Netfish Technologies Europe, Ltd.
Notability Ltd & Catalyst Solutions Plc
NPS (New Planet Solutions)
OM Partners UK
OMI Europe Ltd.
OnDisplay UK Ltd
Online Logistics Limited
Onyx Software
Open Business Solutions
Open Market UK Ltd.
Open Text
Optio Software
Optrak Distribution Software Ltd
Optum
Oracle
Ortems UK Ltd
Paragon Software Systems plc
Peak Technologies
Pegasus Business Software
PeopleSoft
Peregrine Systems Ltd
Pivotal
POMS
Preactor International Limited
Prima Business Control Software
PrimeResponse Ltd

Proasis
Productivity Computer Solutions Ltd
Promis Software Ltd
PTV-Ordis (UK) Ltd.
QAD
Qiva Ltd
Rainbow Business Solutions
Remedy UK
Retek
ROSS Systems (UK) Ltd
Sage Enterprise Solutions
Saleslogix
SAP
SCT
Sequencia (UK) Ltd
Sexy Software Ltd
SSI
Staffware plc
Strategix
Sun-Netscape Alliance
Swift Computing Limited
Swisslog Software (UK) Ltd
Symix Systems Inc
Synchromatic Ltd
Syncra Systems, Inc
Synergy Logistics Ltd.
SynQuest, Inc.
Systemware Services Limited (SSL)
TABS Ltd
The Control Group Limited
The Foxboro Co.

The PCMS Group Plc

Tools Ltd

Tranmit plc

Trenscomm UK Ltd.

TXT

Unicorn Systems (UK) Ltd

USDATA

Vastera Ltd.

Vertex Interactive (UK) Ltd

Viewlocity UK Ltd.

Vignette

Wax Digital Ltd

webMethods Ltd.

Westland Systems Ltd

WeSupply Limited

Wizard Information systems, Ltd

Wonderware

Xansa

Xelus

APPENDIX 4.4

Invalid addresses (12)

Adapta Soutions

Ardent Software UK

Artemis Business Solutions

BEC (UK) LTD

Damgaard Ltd.

Infbank International

Mincom Services Pty Ltd

OnDisplay UK Ltd

Sequencia (UK) Ltd

Sun-Netscape Alliance

Vertex Interactive (UK) Ltd

Wizard Information systems, Ltd

APPENDIX 4.5

No SCM software offered by the company (3)

Gomark Ltd.
Intellident Ltd
Lawson Software

APPENDIX 4.6

Companies which replied after the first round of the survey and their product name(s) (30)

Apriso (CIM+)
Aurega Integrated Manufacturing (Clarif~I)
Cincom Systems (UK) Limited (MANAGE: ENTERPRISE)
Cincom Systems (UK) Limited (CONTROL: 2001)
Diagonal Computer Services (SAP Supply Chain Management)
DynaSys UK Ltd (SKEP eXtended Solutions)
Frontstep (UK) Ltd (Frontstep Supply Chain Centre)
FuturMaster (FuturMaster)
FWL Technologies Limited (Fulfillment SCE)
Honeywell Hi-Spec Solutions (POMS MES, CMS + eSpec)
infor:swan business solutions (infor:com)
MARC Global Services (MARC-SC (WMS), Factorysuite, Factoryworks)
MAX International Ltd (MAX)
McGuffie Brunton Ltd (Impact Encore)
Mercia Software (Mercia Lincs)
Minerva Industrial Systems Plc (MFG Pro)
Navision (Navision Axapta)
Open Business Solutions (Calidus-E)
Open Text (Livelink)
Ortems UK Ltd (Ortems)
Preactor International Limited (Preactor APS)
Productivity Computer Solutions Ltd (Pronto Enterprise Management System)
Qiva Ltd (Qiva Solutions)
Sage Enterprise Solutions (Enterprise II)
SAP (MYSAP.COM)
SCT (iProcess)

Syncra Systems, Inc (Syncra XT)

TXT (TXT.SC&CM)

WeSupply Limited (The Wesupply Chain Solution)

Xelus (Xelus Plan)

APPENDIX 4.7

Covering letter in the second round of questionnaires

4PS SIG - Institute of Operations Management, UK
University of Huddersfield, UK

April 2002

Re: Survey of Supply Chain Management Software

Dear Sirs,

The enclosed questionnaire was already sent to you in the beginning of summer 2001. Although there has been an excellent response rate to the questionnaire, we still haven't received your reply. I am sending it to you for the second time in case the first copy got lost in the post or was delivered to the wrong addressee.

I sincerely hope that you will take this chance to have your product included in the survey whose main task is to study the market for Supply Chain Management software and identify the current level of development of Supply Chain Management tools and methods. You will find out that filling in the simple questionnaire will enable us to make a large number of software consultants and users aware of the competitive position of your product on the Supply Chain Management software market.

Thank you very much for your time!

Yours sincerely,

Ivelina Ivanova

School of Engineering
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Queensgate
Huddersfield HD1 3DH
United Kingdom

e-mail: i.ivanova@hud.ac.uk
Tel: +44 (0)1484 473088 (during office hours)
Mobile: +44 (0)77528 72332

APPENDIX 4.8

Companies included in the second round (48)

AquiTech Ltd
Ariba
Ascent
AspenTech Limited
Byford Computer Services Limited
Catalyst International
Chess Logistics Technology Ltd.
Demand Solutions (Europe) Ltd
Demantra
Descartes Systems Group
Epicor Sotfware Limited
Ethitec
EXE Technologies
Extricity, Inc. Europe
Geac Enterprise Solutions
GLOVIA Inc.
Halstead Software Limited
i2 Technologies UK
IBS (International Business Systems)
IFS
ILOG Ltd
Insight Logistics Ltd
Intentia (UK) Ltd
InterBiz
J.D.Edwards (UK) Ltd
JDA International Ltd
Lilly Software Associates Ltd

LIS
Logility International
Lynx Commercial Systems
Manhattan Associates
Manugistics UK Ltd
McHugh Software International
NPS (New Planet Solutions)
OM Partners UK
Online Logistics Limited
Optio Software
Oracle
PeopleSoft
Prima Business Control Software
ROSS Systems (UK) Ltd
SSI
Strategix
Swisslog Software (UK) Ltd
Synergy Logistics Ltd.
Unicorn Systems (UK) Ltd
Vastera Ltd.
Viewlocity UK Ltd.

APPENDIX 4.9

Companies which replied to the second round and their product (6)

EXE Technologies (Exceed)

Intentia (UK) Ltd (Movex)

JDA International Ltd (Portfolio)

Lilly Software Associates Ltd (Visual Enterprise)

OM Partners UK (OMP Supply Chain Suite)

Swisslog Software (UK) Ltd (WarehouseManager)

APPENDIX 5.1

Framework for the expert interviews

Framework for the expert interviews

A. Introduction to the interview

1. What I am doing.
2. Who recommended him/her to me as a SCM software expert.
3. Objectives of the expert interview

B. Discussion topics

In general about SCM (supply chain management) and SCM software

1. Would you agree that SCM means both SCE (supply chain execution) and SCP (supply chain planning)?
2. Would you agree that the majority of the current systems which are called SCM systems, are mainly SCE systems and not fit for planning purposes?
3. Is there a generally accepted concept for supply chain and SCM? How would you define them?

About particular SCM software products

4. Which SCM software product(s) are you familiar with (by implementation, consultancy, development, etc)?
5. Can you fill in the software questionnaire about that/those product(s)?
6. Can you describe in brief the implementation, etc of the software product(s) along with any problems encountered in the process?
7. Has the implementation been considered to be successful?
8. Are all functionalities utilised? I.e. is the system utilised as a real SCM system?
9. After the post-implementation analysis of the success, do users need additional functionalities? If yes, what are they?
10. What problems have the users faced in terms of:
    a) user-friendliness
    b) technology

c) integration/compatibility with other generic systems

d) need to adapt the system to the changing processes/operations within the supply chain

e) availability of data to feed into the system?

f) compatibility with supply chain partners' systems

g) ....

About the future requirements to supply chain management and SCM software

11. Are today's supply chains managed efficiently? If not, what are the flaws of today's supply chain management?
12. Which areas of SCM are in most urgent need of improvement?
13. What planning functionalities would a SCM system need to have in addition to its SCE functions?
14. Are you aware of any omissions in the understanding of software developers of what the users need? Do they lack understanding of supply chain processes?
15. In what are future supply chains going to be different from today's supply chains?
16. What will the future supply chains demand from the future approaches to SCM? What are the future challenges to the supply chain manager?
17. How can the development of SCM software help meet those challenges? (what functions will SCM systems need?)

C. Concluding remarks

APPENDIX 6.1

Diagrametric supply chain map of the supply chain of Adams

Adams - Diagrametric Supply Chain Map

Glossary

AI — Artificial Intelligence

AI is the branch of computer science concerned with making computers behave like humans.

APS — Advanced Planning Systems, later referring to Advanced Planning and Scheduling Systems

APS is a software system that uses intelligent analytical tools to perform finite scheduling and produce realistic plans. This type of software application helps companies manage customer demand and product supply, taking into consideration constraints such as plant capacity.

ATM — Automated Teller Machine

An **ATM** allows a bank customer to conduct their banking transactions from almost every other ATM machine in the world.

B2B — Business To Business

B2B is an Internet strategy of dealing directly with businesses, rather than consumers.

B2C — Business To Customer

B2C is used to describe Internet commerce between a business and a consumer.

BOM — Bill of Materials

BOM is a complete list of the components which make up the finished goods. The BOM should include part number, quantity, and description. An indented BOM includes descriptions of sub assemblies and how they relate to the finished goods. The BOM is an essential part of the logistics management process.

CIM — Computer-Integrated Manufacturing

CIM refers to the integrated use of computer aided techniques in manufacturing. This includes CAD, CAE, CAM, etc, but the term is interpreted in a variety of ways by various suppliers of CIM solutions. The main requirement of CIM is a central shared database that may be accessed by the different disciplines deployed during the manufacturing process, such as design, development, manufacture, distribution, billing etc. CIM is a superset of CAM

CRM — Customer Relationship Management

CRM an information industry term for methodologies, software, and usually Internet capabilities that help an enterprise manage customer relationships in an organized way. For example, an enterprise might build a database about its customers that described relationships in sufficient detail so that management, salespeople, people providing service, and perhaps the customer directly could access information, match customer needs with product plans and offerings, remind customers of service requirements, know what other products a customer had purchased, and so forth.

CRP — Continuous Replenishment Planning

CRP is based on the principle of placing suppliers in charge of replenishing retailer's inventories of supplier's goods, usually yielding lower inventory investments and higher turns.

CRP — Capacity Requirements Planning

CRP enables balancing the production plans with machine and manpower capacity. It gives the visibility to optimize production resources, and make knowledgeable overtime, subcontracting, and work transfer decisions.

DFD — Data Flow Diagram

DFD is a diagram which models the flow of data through the program as it operates. The top level is known as a context diagram; in subsequent levels processes are decomposed into subprocesses. This recursion ends when a process is deemed small enough to code without error.

DPF — Demand Planning & Forecasting

DPF extends the traditional view of logistics and supply chain planning driven by forecasting, to include the causal impacts of demand planning. This approach is encompassed within a demand chain concept that aims to create competitive advantage through integrated demand management, demand forecasting, inventory planning and production planning.

DRP — Distribution Requirements Planning

DRP is a software application used to plan inventory requirements in a multiple plant/warehouse environment. DRP may be used for both distribution and manufacturing.

EDI — Electronic Data Interchange

EDI is a standard format for exchanging business data and documents (purchase orders, invoices, payments, inventory analyses, and others). The standard is ANSI X12 and it was developed by the Data Interchange Standards Association. ANSI X12 is either closely coordinated with or is being merged with an international standard, EDIFACT.

EFM — Enterprise Fleet Management

EFM encompasses all the tools and methods for managing the fleet of vehicles throughout the enterprise, including route optimisation, vehicle allocation and scheduling, transport cost reduction, etc.

EPSRC — Engineering and Physical Sciences Research Council

EPSRC is the UK Government's leading funding agency for research and training in engineering and the physical sciences.

ERP — Enterprise Resource Planning

ERP is an industry term for the broad set of activities supported by multi-module application software that help a manufacturer or other business manage the important parts of its business, including product planning, parts purchasing, maintaining inventories, interacting with suppliers, providing customer service, and tracking orders.

FCS — Finite Capacity Scheduling

FCS is the allocation of resources over time to perform a set of tasks such that task precedence constraints and resource capacity constraints are not violated, and overall deadline goals are met to the best extent possible.

GLS — Global Location System

GLS is a triangulation system used to locate a vehicle and convey that information to a central management facility.

GPRS — General Packet Radio Service

GPRS is a GSM data transmission technique that does not set up a continuous channel from a portable terminal for the transmission and reception of data, but transmits and receives data in packets. It makes very efficient use of available radio spectrum.

GPS — Global Positioning System

GPS refers to satellite-based radio positioning systems that provide 24 hour three-dimensional position, velocity and time information to suitably equipped users anywhere on or near the surface of the Earth (and sometimes off the earth). GPS technology is used in a wide range of applications, including maritime, environmental, navigational, tracking and monitoring.

G.R.N. — Goods Received Note

G.R.N. is a formal document issued in acknowledgement of receipt of goods or materials.

GTM — Global Trade Management

GTM tools help companies simplify, automate and accelerate global trade through taking advantage of trade preference programs, the most favourable local economic conditions, advanced sourcing and distribution strategies and conforming to current trade laws and regulations.

ICAEW — Institute of Chartered Accountants in England & Wales

ICAEW The Institute of Chartered Accountants in England & Wales is the largest professional accountancy body in Europe, with over 125,000 members.

ICAM — Integrated Computer Aided Manufacturing

ICAM aims at developing 'generic subsystems' which can be used by a large number of companies to provide a significant upgrade to the industry as a whole. These subsystems provide support for common manufacturing functions such as management of information, shop floor scheduling, and materials handling.

IDEF — Integrated DEFinition

IDEF is a group of modelling methods that can be used to describe operations in an enterprise. Originally developed for the manufacturing environment, IDEF methods have been adapted for wider use and for software development in general. IDEF methods are used to create graphical representations of various systems, analyze the model, create a model of a desired version of the system, and to aid in the transition from one to the other. IDEF is used along with gap analysis.

ISCM — Improved Supply Chain Management

ISCM is a term, introduced in the present dissertation, which refers to the management of a supply chain at a higher level of sophistication, to acknowledge the need of coordination and integration throughout the entire supply chain.

HRM — Human Resource Management

HRM encompasses all the activities related to the recruitment, hiring, training, promotion, retention, separation, and support of faculty and staff.

IMC — Inventory Monitoring and Control

IMC encompasses all the activities related to counting and monitoring the items actually in inventory; recording and retrieving the precise locations of items in inventory; recording changes to inventory frequently and precisely so that accurate inventory control is made possible; and anticipating inventory needs in order to re-order "just in time" and to plan for inventory handling requirements.

IMI — Innovative Manufacturing Initiative

IMI is collaboration between industry, academia and government to develop and demonstrate innovative technology to design, manufacture and deliver products to the customer.

IT — Information Technology

IT a term that encompasses all forms of technology used to create, store, exchange, and use information in its various forms (business data, voice conversations, still images, motion pictures, multimedia presentations, etc.).

KPI — Key Performance Indicators

KPI are measures designed to track a critical performance variable over time.

MES — Manufacturing Execution System

MES is a term used to describe systems that track and manage all aspects of a job in real time while it is in the execution phase or in process. It may include resource management, capacity scheduling, maintenance management, statistical quality control, laboratory information management, process management, data collection, plant wide document management and process optimisation. MES is focused on the short term and may link to ERP/MRPII software for higher level planning and control tasks.

MPS — Manufacturing Planning and Scheduling
MPS systems provide functionality which helps with all the activities related to planning and scheduling within a manufacturing enterprise.

MPS — Master Production Schedule
MPS is a realistic, detailed, manufacturing plan for which all possible demands upon the manufacturing facilities (such as available personnel, working hours, (management) policy and goals) have been considered and are visualized. The MPS is a statement of what the company expects to produce and purchase expressed in selected items, specific quantities and dates.

MRP — Material Requirements Planning
MRP is a set of techniques that uses bill of material data, inventory data, and the master production schedule to calculate requirements for materials.

MRPII — Manufacturing resources planning
MRPII is the consolidation of material requirements planning (MRP), capacity requirements planning (CRP), and master production scheduling (MPS). MRP was originally designed for materials planning only. When labour and machine (resources) planning were incorporated it became known as MRPII. Today the definition of MRPII is generally associated with MRP systems.

NDO — Network Design and Optimisation
NDO is a comprehensive tool set designed to analyse the variables associated with operating an end-to-end supply network — including costs, capacity, and geography — and optimise the network to achieve the lowest possible costs and the highest possible profits, all while maintaining target customer service levels.

NPD — New Product Development
NPD is the creation of new products needed for growth or to replace those in the decline stage of their life-cycle; the stages in the new product development process are commonly listed as idea generation; screening; concept development and testing; the formulation of marketing strategies; business analysis; production; market testing; and commercialisation.

NVO — Networked Virtual Organisation
NVO is a model in which an organisation teams with two or more external organisations, all connected by a common network infrastructure, to bring a new product or service to market. The NVO model fosters agility and efficiency by prescribing the adoption of enabling technologies to increase organisational competitiveness.

OM — Order Management

and may link to ERP/MRPII software for higher level planning and control tasks.

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OM — Order Management

OM comprises added-value functions associated with the pre-trade, trade and post-trade processing of orders including, for example, providing for basket and programme trading, bulking, splitting and netting of orders.

OEM — Original Equipment Manufacturer
OEM is a company that manufactures a given piece of hardware, unlike a value-added reseller, which changes and repackages the hardware to sell it under its own brand.

PCB — Printed Circuit Board
A **PCB** a rigid board typically made from fibreglass, approximately 0.060" thick, and used for mounting electronics components as part of a larger assembly. This board has wiring patterns formed by traces of a conductor, such as copper, fused to the board. The wiring pattern is created either by depositing the conductor on the board or by starting with a solid film of the conductor and etching away what is not needed.

QMP — Quality Manufacturing Procedure
QMP is a formal manufacturing procedure that is in place to ensure that the processes and the final product meet a certain quality standard or a set of standards.

QPM — Quality Procedures Manual
QMP is a manual that specifies manufacturing procedures so that they meet a quality standard.

RF — Radio Frequency
RF is a frequency within the electromagnetic spectrum normally associated with radio wave propagation. Also used generally to refer to the radio signal generated by the system transmitter, or to energy present from other sources that may be picked up by a wireless receiver

RFID — Radio Frequency Identification
RFID refers to the technology that uses devices attached to objects that transmit data to an RFID receiver. These devices can be large pieces of hardware the size of a small book like those attached to ocean containers or very small devices inserted into a label on a package. RFID has advantages over bar codes such as the ability to hold more data, the ability to change the stored data as processing occurs, does not require line-of-sight to transfer data and is very effective in harsh environments where bar code labels won't work.

ROI — Return on Investment
ROI is a term describing the calculation of the financial return on a business policy or initiative that incurs some cost. ROI may be measured in terms of a payback period for the investment, or as a percentage return on a cash outlay, or as the discounted net present value of free cash flows of an investment‹there are many different ways to calculate it.

RTLS — Real Time Location System

RTLS are fully automated systems that continually monitor the locations of assets and personnel. An RTLS solution typically utilizes battery-operated radio tags and a cellular locating system to detect the presence and location of the tags.

SAV Seddon Atkinson Vehicles

SC Supply Chain
A **SC** comprises the physical, financial, and information networks that involve the movement of materials, funds, and related information through the full logistics process, from the acquisition of raw materials to delivery of finished products to the end user. The supply chain includes all vendors, service providers, customers, and intermediaries.

SCE Supply Chain Execution
SCE is a part of SCM that deals with day-to-day, transactional issues.

SCM Supply Chain Management
SCM is the process, which is triggered by a customer order or by forecasted demand, of moving goods from the raw materials stage, supply, production, and distribution at a profit of the required product to the end customer with the ultimate objective of meeting customer requirements.

SCND Supply Chain Network Design
SCND is a decision support tool which enables the user to solve strategic problems and carry out alternative strategic planning scenarios by planning the supply chain on an aggregated level.

SCP Supply Chain Planning
SCP is a part of SCM that deals with the strategic decisions regarding the supply chain. SCP is concerned with the development and implementation of strategies that improve cost efficiency, increase business effectiveness, and create synergies and collaboration across companies.

SE Special equipment

SCEM Supply Chain Event Management
SCEM is concerned with anticipating breakdowns in plans and schedules and responding rapidly to disruptions. SCEM monitors operations, provides alerts when problems arise, and measures performance. It also improves visibility across all departments, business units, and companies.

SME Small and Medium Sized Manufacturing Enterprise
SMEs are defined by the European Commission as independent enterprises that have fewer than 250 employees, and an annual turnover not exceeding €40/£25 million or a balance-sheet total not exceeding €27/£17 million (extract from the 96/280/EC, Commission Recommendation of 3 April 1996).

SMT Surface Mount Technology

SMT is a high-density electronic component mounting alternative used for compactness and automated assembly economies. Installed surface mounted devices are easily recognized by their wireless, direct solder connections to a printed circuit board.

SOM — Sales Order Management
SOM is the process of managing sales orders (contractual agreements between a sales organisation and a sold-to party about delivering products or providing a service for defined prices, quantities and times) from entry through fulfilment.

SOP — Sales and Operations Planning
SOP normally consists of a series of meetings, finishing with a board level meeting at which key long term decisions are taken and the current progress against the Business Plan is reviewed.

SPM — Service and Parts Management
SPM s the process of planning and aligning service parts inventories, resources, and processes to ensure optimal customer service and response with minimal risk and cost.

SRM — Supplier Relationship Management
SRM is a comprehensive approach to managing an enterprise's interactions with the organizations that supply the goods and services it uses. The goal of SRM is to streamline and make more effective the processes between an enterprise and its suppliers.

TMS — Transportation Management System
TMS is a software application that facilitates the procurement of transportation services, the short-term planning and optimisation of transportation activities, and the execution of transportation plans. It also involves continuous analysis and collaboration.

TOC — Theory of Constraints
TOC is a management philosophy developed by Dr. Eliyahu M. Goldratt that is broken down into three interrelated areas - logistics, performance measurement, and logical thinking. Logistics include drum-buffer-rope scheduling, buffer management, and VAT analysis. Performance measurement includes throughput, inventory and operating expense, and the five focusing steps. Logical thinking includes identifying the root problem (current reality tree), identifying and expanding win-win solutions (evaporating cloud and future reality tree), and developing implementation plans (prerequisite tree and transition tree).

VMI — Vendor-Managed Inventory
VMI is a term used to describe the process of a supplier managing the inventory levels and purchases of the materials he supplies. Vendor managed inventory reduces internal costs associated with planning and procuring materials and enables the vendor to better manage his inventory through higher visibility to the supply chain.

VPN — Virtual Private Network

VPN is a network that is constructed by using public wires to connect nodes, set up solely for the users of a single company. These networks use encryption and other security mechanisms to ensure that only authorized users can access the network and that data cannot be intercepted.

WMS — Warehouse Management System

WMS is software that integrates mechanical and human activities with an information system to effectively manage warehouse business processes and direct warehouse activities. WMS automates receiving, put away, picking, and shipping in warehouses and can prompt workers to do inventory cycle counts.

YTD — Year to Date